GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: September 9, 1977

Project Title: Energy Conservation and Management Program for St. Joseph's Hospital, Savannah, Georgia

Project No: A-2044

Project Director: ~~D. Wilmer~~ D. Willmer

Sponsor: St. Joseph's Hospital, Savannah Georgia 31406

Agreement Period: From 8/15/77 Until 12/14/77

Type Agreement: Ltr. Dtd. 8/15/77

Amount: $9,750

Reports Required: Final Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Sister M. Faith
Assoc. Admin.
St. Joseph's Hospital, Inc.
11705 Mercy Blvd.
Savannah, Georgia 31406

Defense Priority Rating:

Assigned to: Technology & Development Laboratory (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
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- Project Code (GTRI)
- Other

CA—3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
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SPONSORED PROJECT TERMINATION

no action
GOS

Date: 7/18/78

Project Title: Energy Conservation and Management Program for St. Joseph's Hospital, Savannah, Ga.

Project No: A-2044

Project Director: ~~D. Wilmer~~ D. Willner

Sponsor: St. Joseph's Hospital, Savannah, Ga. 31406

Effective Termination Date: 4/13/78

Clearance of Accounting Charges: All clear

Grant/Contract Closeout Actions Remaining:

- x Final Invoice ~~and Closing Documents~~
- Final Fiscal Report
- Final Report of Inventions
- Govt. Property Inventory & Related Certificate
- Classified Material Certificate
- Other ______

Assigned to: Technology & Development (School/Laboratory)

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CA-4 (3/76)

A-2044

ENERGY MANAGEMENT AND CONSERVATION PROGRAM
FOR
SAINT JOSEPH'S HOSPITAL
SAVANNAH, GEORGIA

by

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The Georgia Tech Energy Team would like to thank the staff of Saint Joseph's Hospital for their cooperation throughout the project. The enthusiastic support and intent interest in the project expressed by Sister Mary Faith, R.S.M., Associate Hospital Administrator, is deeply appreciated. Special thanks go to Mr. Fred J. de Borde, Chief Engineer, and his fine staff for their assistance during the on-site hospital surveys. Mr. de Borde and Mr. Tom White provided valuable insights into the physical plant and overall hospital operations, and Mrs. Susan Smith assembled the necessary energy data for use in the energy audit.

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I. EXECUTIVE SUMMARY

The worldwide economic leadership the United States has attained was built on abundant and inexpensive domestic energy resources. These plentiful resources have been the cornerstone of America's advanced technological and industrialized society. The energy budget required to operate our economy consists of:

Source	Percent of Total Energy Budget
Petroleum	47
Natural Gas	27
Coal	18
Hydroelectric	4
Nuclear	3
Other	1

These figures illustrate our dependence on petroleum products and natural gas for supplying almost three-fourths of our required energy.

America, however, faces a serious domestic shortage of these two key raw energy forms. Since the 1950's, the nation has not been able to meet the energy demand with domestic supplies. This shortfall has been met by importing petroleum from other countries. The trend to import more and more petroleum has continued, with America now importing 51% of its petroleum supplies from foreign nations.

The dangers inherent in this approach were dramatized during the 1973-1974 oil embargo imposed on the United States by the OPEC oil consortium. The embargo and price escalation of petroleum that followed focused the American public's attention on the need for additional exploration for traditional energy sources, continued research and development in emerging energy technologies, and more efficient use of existing resources. Of these three alternatives, the latter which is termed energy conservation, has been recognized by consumers and the government to be the approach that will allow the United States to buy time while new supplies are being discovered and new sources are being developed.

Energy conservation is energy management. It embodies the concept of utilizing energy efficiently and effectively. Existing buildings usually consume far more energy than required. Such wastefulness was of little consequence during the years of inexpensive energy before the embargo; however, energy costs are quickly becoming an increasingly greater portion of an operating budget. Hospitals in this instance are no exception. It is estimated that of the nation's 7,200 existing hospitals more than 90% were built and/or designed before 1973/1974 and, therefore, are inefficient by today's energy standards. Hospital administrators are, in particular, under pressure to reduce energy consumption through conservation in order to reduce and maintain reasonable energy expenditures.

Although the statistics on our dwindling energy supplies and growing demand are constantly presented in the media, the commitment to an energy conservation philosophy must be made individually. The administration of Saint Joseph's Hospital has made that commitment. This study provides the framework for developing a long-term energy conservation program for the hospital to meet this commitment. The Georgia Tech Energy Team deeply appreciates the leadership exhibited by the hospital administration in implementing varied conservation procedures and the opportunity to further these with a program designed to establish a systematic framework for continued energy conservation.

Approach to Energy Conservation

The first task in the project was to develop a history of energy usage and costs at Saint Joseph's over the past five years. Data were collected on electricity, natural gas, and fuel oil for the five fiscal years from 1972-1973 to 1976-1977. Data for this time period were fairly complete and estimates of consumption and costs were required for only a few months. These data were used to develop the energy audit of the hospital facility and to establish the basic energy year for consumption and cost. The reductions in consumption and cost resulting from the conservation recommendations are applied directly to the basic energy year.

Once the data analyses were completed, the Tech Energy Team, in cooperation with personnel from the hospital's Engineering Department, conducted three on-site surveys of the hospital facility. Heating, cooling, and lighting systems were inspected and lighting intensity measurements were made throughout the hospital. Age, type of construction, window design, and other pertinent structural characteristics of the building were noted from the hospital plans and specifications and the visual appraisals. Thermographs (infrared photographs) pinpointing areas of heat loss from the hospital structure were made during the last survey visit.

Based upon the energy audit and the results from the hospital surveys, an energy management program and energy conservation recommendations were developed for Saint Joseph's. The program consists of methodologies for documenting the effects of present and future conservation efforts. The information necessary to monitor and evaluate energy consumption and costs and the effects of conservation work done in the hospital facility are included. The conservation recommendations consist of detailed discussions on operational modifications and/or improvements to equipment, the physical plant, and the hospital facility for the purpose of saving energy and reducing energy costs.

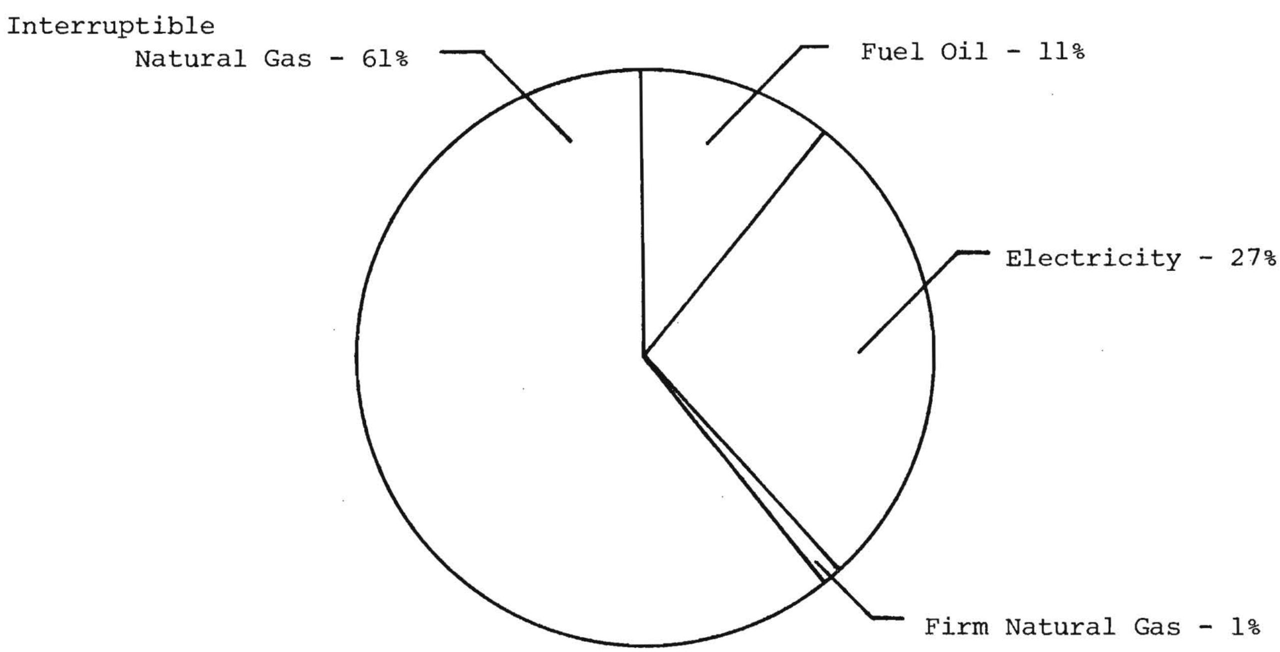
Summary of Energy Savings

The overall goals of Saint Joseph's long-term energy conservation program are (1) to reduce energy consumption to the lowest possible level through efficient operational procedures and minor and/or capital improvements and (2) to effect a downward trend in energy costs based upon reduced consumption to the point of the most efficient usage of energy as described in (1). The energy audit results indicate the trend of increasing energy costs accompanying little or no increases in energy consumption. This means that even though consumption is decreasing annually, costs are remaining the same or increasing due to revised rate structures, fuel adjustments, and across-the-board increases. Saint Joseph's must reach its optimum level of efficient consumption as quickly as possible through conservation efforts and maintain that level in the hospital for its long-range conservation program.

A basic energy year was calculated using the audit results of consumption trends over the past five years. This basic year reflects an average of annual energy consumption over the fiscal years 1975-1976 and 1976-1977. Even though an extremely cold winter was experienced during 1976-1977, consumption of all energy types remained relatively constant compared with usage in previous years. Figure 1 illustrates the hospital's consumption of energy by type calculated from the basic energy year. Interruptible natural gas is the greatest amount of energy consumed in the hospital, meeting 61% of the hospital's needs, with electricity second at 27%. Fuel oil and firm natural gas at 11% and 1%, respectively, complete the total consumption picture for the hospital.

Figure 1

AVERAGE ANNUAL CURRENT ENERGY CONSUMPTION BY TYPE

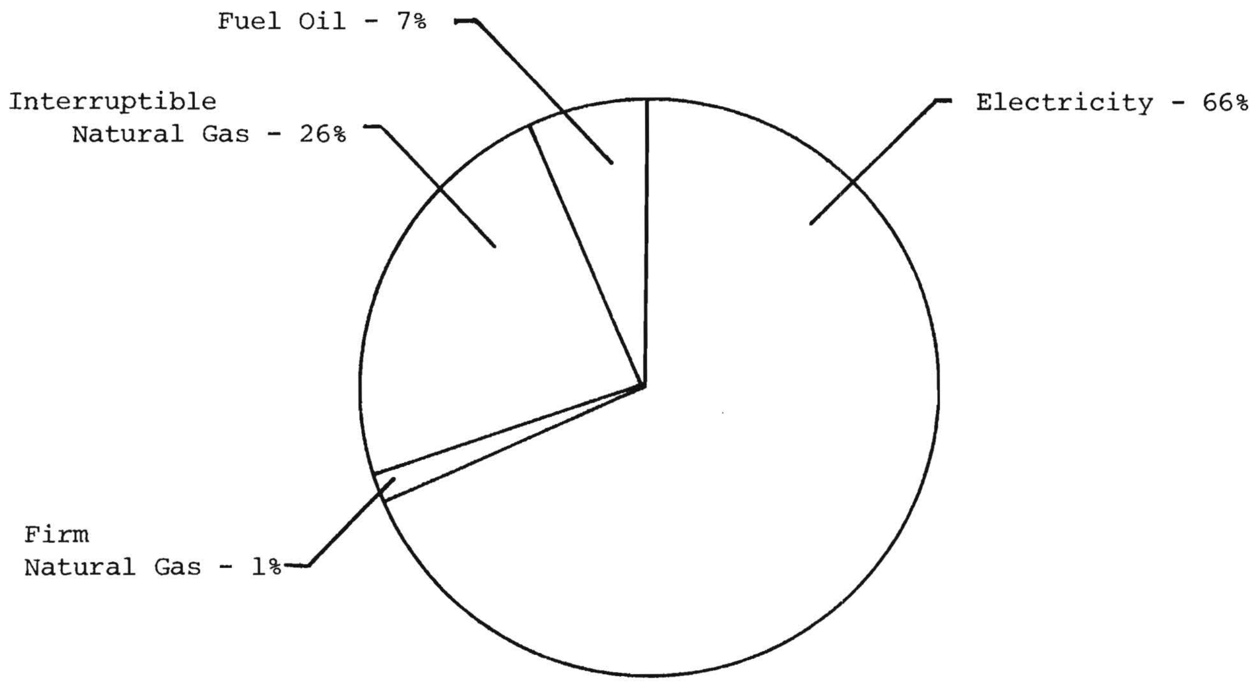


A look at the cost of energy by type for Saint Joseph's in Figure 2 shows that electricity and interruptible natural gas trade places on the graph, with electricity commanding two-thirds of the energy budget and natural gas about one-quarter. Fuel oil costs run 7% of the energy budget and firm natural gas less than 1%. It is interesting to note that both consumption and cost percentages calculated, using actual annual data from the audit, were comparable to the basic energy year.

The basic energy year reflects a total energy usage of 89,722 million BTU at $377,360, based on current (1978) prices for electricity, natural gas, and fuel oil. This basic year is comparable with previous years in energy consumption, before, during, and after the opening of the hospital addition in January 1976. This consumption level represents energy usage that the hospital facility has essentially maintained over the past five years. With this consumption level and cost as the bases for evaluating the impact of future energy conservation actions as recommended in this report, it is estimated that total hospital energy consumption can be reduced 31%, reflecting a saving of 27,814 million BTU and $116,980 in 1978 dollars. These savings will be accomplished with the implementation of all the recommendations discussed in Section V. The rate of implementation of the conservation recommendations will, of course, determine the percentage of long-range energy savings and cost. The conservation recommendations will lead the hospital to the most efficient level of energy utilization that it will need to maintain in the energy management program.

Figure 2

AVERAGE ANNUAL PERCENT ENERGY COSTS BY TYPE[1/]



1/ Based on 1978 average costs for energy.

II. ENERGY AUDIT

The first step in the project was to conduct an audit of energy usage at Saint Joseph's. The major purpose of the audit was to provide the quantitative base for the energy management and conservation program. The other important reasons for the audit were:

- o To indicate areas of potential energy savings
- o To indicate areas of energy waste
- o To provide a base for monitoring and evaluating energy saving ideas
- o To provide a means for verifying billed charges

From the Saint Joseph's energy data, a profile of energy usage over a five-year period from July 1972 to July 1977 was developed. Hospital records for billing charges for electricity from Savannah Electric and Power Company, for natural gas from Savannah Gas Company, and for fuel oil were used to summarize trends in seasonal usage, quantities of energy by type, and energy operating costs. Only two months of electrical and natural gas data were unavailable over the five-year audit period. These data were estimated, using previous consumption and costs from similar operating years. A discussion of electrical, natural gas, and fuel oil energies is presented in the following paragraphs.

Electrical Energy

Electrical usage is metered under one account by Savannah Electric and Power Company for the whole hospital facility. The hospital purchases power under their rate schedule "C-5 Hospital Service." This rate is fairly unusual when compared to the typical electric rates applicable to hospitals because the "demand" component is not as strong a factor as might be expected. The C-5 rate has:

1. A 70% instead of a 95% demand carry-over
2. No summer-winter rate differential
3. A charge per kilowatt of demand that is quite reasonable

A review of the current electric power bills reveals that the present demand control program of the hospital is functioning and is providing adequate control. However, if any of the current aspects of the C-5 rate change, the hospital should review their demand control program. Because the factors affecting electric utility cost are similar for all utilities, it is reasonable to assume that these changes may occur. While demand does not ordinarily affect total energy consumption, it can sharply affect the cost paid for electricity. The hospital should study carefully any new or proposed rate change for its implication.

Graph 1 illustrates the trend in electrical consumption in kilowatt hours (KWH) and costs for the hospital over the audit period. Costs for electricity have continued to rise since 1972, while consumption has remained relatively constant. One great increase in consumption occurred during the construction of the new facility in 1975. Consumption of natural gas also increased during this same period, which indicates that construction had the effect of increasing the use of energy throughout the facility. The additional space was occupied during 1976 when consumption returned to levels equivalent to the years before the construction. With this additional space, consumption should have increased; however, the hospital's implementation of various energy conservation procedures in 1976 stabilized consumption levels over the past two years.

Table 1 summarizes the total electrical consumption and cost per year for Saint Joseph's. The annual percentage change in million BTU illustrates the relatively constant level of usage. The greatest increase was experienced in 1977, which indicates that greater efforts at conservation must be initiated and sustained.

Table 1

SUMMARY OF ELECTRICAL ENERGY CONSUMPTION AND USES1/

Year	KWH	Million BTU2/	% Change in Million BTU	Actual Cost3/
1972-1973	6,809,751	23,242	-	$ 89,665
1973-1974	6,884,625	23,497	+1	121,852
1974-1975	7,044,690	24,043	+1	171,323
1975-1976	6,882,000	23,488	-2	178,156
1976-1977	7,389,000	25,219	+7	218,811

1/ Consumption and cost data reflect estimates for months in which data were not available.

2/ Million BTU = KWH x 3,413, where a British Thermal Unit (BTU) is defined as the heat required to raise one pound (1 lb.) of water one degree Farenheight (1°F).

3/ Recorded to nearest dollar.

Graph 1 was designed to be used in coordination with the energy management program discussed in Section III. By plotting consumption and cost over time, the trend in electrical usage can be monitored annually. The long-range goal of the hospital will be to pursue a downward consumption trend to the point where the most efficient hospital operation is maintained. Since Saint Joseph's has no control over the rising cost of electricity, decreasing usage to the greatest extent possible is the best alternative.

Plotting the overall trend of electricity also allows the calculation of seasonal adjustments to meet fluctuating weather conditions. Graph 2 is a plot of the typical percentage of seasonally adjusted electricity used per month and per quarter, and is derived from actual operating characteristics over the past five years. Future electrical usage can be compared to this graph to determine if any adjustments will be needed to meet electrical demand in a particular time period or in case of extreme climatic conditions in any given year.

Natural Gas and Fuel Oil

Saint Joseph's burns both natural gas and fuel oil in its boilers for the production of steam. The hospital is supplied with natural gas on both firm and interruptible schedules by Savannah Gas Company. In December, January, and February of every audit year, natural gas was interrupted and the boilers switched over to fuel oil. Fuel oil was used 95% of the time during January and February of 1977. During these same months in previous years, fuel oil only contributed 25% of the total energy required for steam production. As the future availability of natural gas becomes more uncertain, the hospital can expect to use even greater quantities of fuel oil for longer periods of time. Graph 3 depicts the general trend in interruptible natural gas and fuel oil consumption to produce steam for hospital functions. To compare differences in yearly usage, natural gas and fuel oil must be converted to the common base of million BTU and added together in the appropriate months. The results of this, as plotted in Graph 3, illustrate the general increase in cost and the relatively constant consumption of these energies over time.

Table 2 summarizes the total costs and consumption for both natural gas and fuel oil during the audit period. Costs for these energies have nearly tripled over those in 1972-1973. The hospital now pays an average of $1.81 per million BTU for natural gas and $0.38 per gallon for fuel oil (1977-1978 rates).

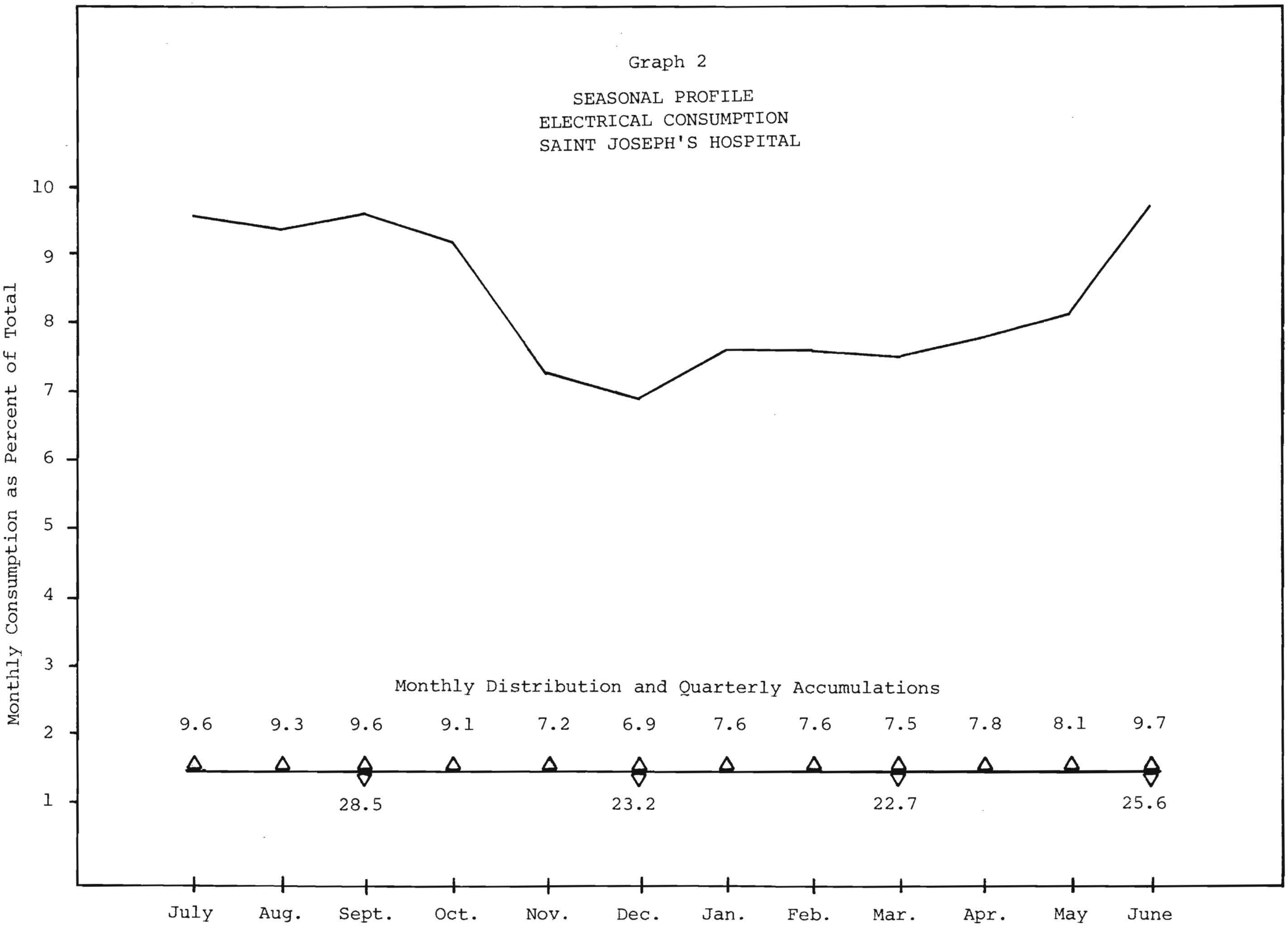

Graph 2
SEASONAL PROFILE
ELECTRICAL CONSUMPTION
SAINT JOSEPH'S HOSPITAL
Monthly Consumption as Percent of Total
10
9
8
7
6
5
4
3
2
1
Monthly Distribution and Quarterly Accumulations
9.6
9.3
9.6
9.1
7.2
6.9
7.6
7.6
7.5
7.8
8.1
9.7
28.5
23.2
22.7
25.6
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June

Table 2

SUMMARY OF STEAM PRODUCING ENERGY AND COSTS[1/]
(Interruptible Natural Gas and Fuel Oil)

Year	Million BTU[2/]	% Change from Preceding Year	Actual Cost[3/]
1972-1973	76,741	-	$ 45,011
1973-1974	88,979	+16	76,686
1974-1975	91,999	+ 3	113,226
1975-1976	61,400	-33	91,675
1976-1977	66,897	+ 9	121,121

1/ Consumption and cost data reflect estimates for months in which data were not available.

2/ Million BTU Natural Gas = Therms ÷ 10
Million BTU Fuel Oil = Gallons x 140,000

3/ Rounded to nearest dollar.

If these current costs were applied to past usage of these energies, the hospital would have had the following bills.

Year	Total Costs 1977-1978 Rates	Actual Costs
1972-1973	$142,376	$ 45,011
1973-1974	164,688	76,686
1974-1975	171,137	113,226
1975-1976	113,558	91,675

These data re-emphasize the need for creating a downward energy trend to achieve the most efficient operating level so that the effect of rising energy costs can be controlled.

To monitor annual trends, interruptible natural gas and fuel oil data should be combined and plotted as a continuation to Graph 3 (see full discussion in Section III). This provides the hospital with a continuous and complete history of operating data. These plots can then be used to monitor and evaluate consumption levels and costs as the conservation program elements are implemented.

To date, the hospital has only been keeping records of the amount of fuel oil ordered and purchased in a particular month. Although this has not skewed the audit data, fuel oil ordered in September and March as recorded for some of the years was obviously not used during these months. Fuel oil data should be summarized in the future based on actual usage during a month. It is recommended that the amount of fuel oil in the tank be measured on the same day as the interruptible gas meter is read by Savannah Gas Company. The amount of fuel oil actually used in the month can then be calculated so that a more accurate portrayal of fuel oil usage can be included in the consumption trend.

Graph 4 illustrates the percent usage of steam production energies per month and per quarter during a typical year. The seasonal consumption trend was calculated using the basic energy year for these energies. This trend should be used with the management program to monitor the amount of these energies consumed per month and quarter. By using this trend, adjustments in consumption can be made, if necessary, during the year to meet requirements resulting from extreme climatic conditions or fuel shortages.

Firm Natural Gas Energy

Although firm natural gas only amounts to 1% of the total hospital energy and energy costs, it is important to characterize its usage. Firm natural gas is delivered to Saint Joseph's to operate the incinerator, kitchen, laboratory, and dental operating areas. Graph 5 shows that the amount of firm natural gas used in the hospital and its cost have been slowly increasing since 1972.

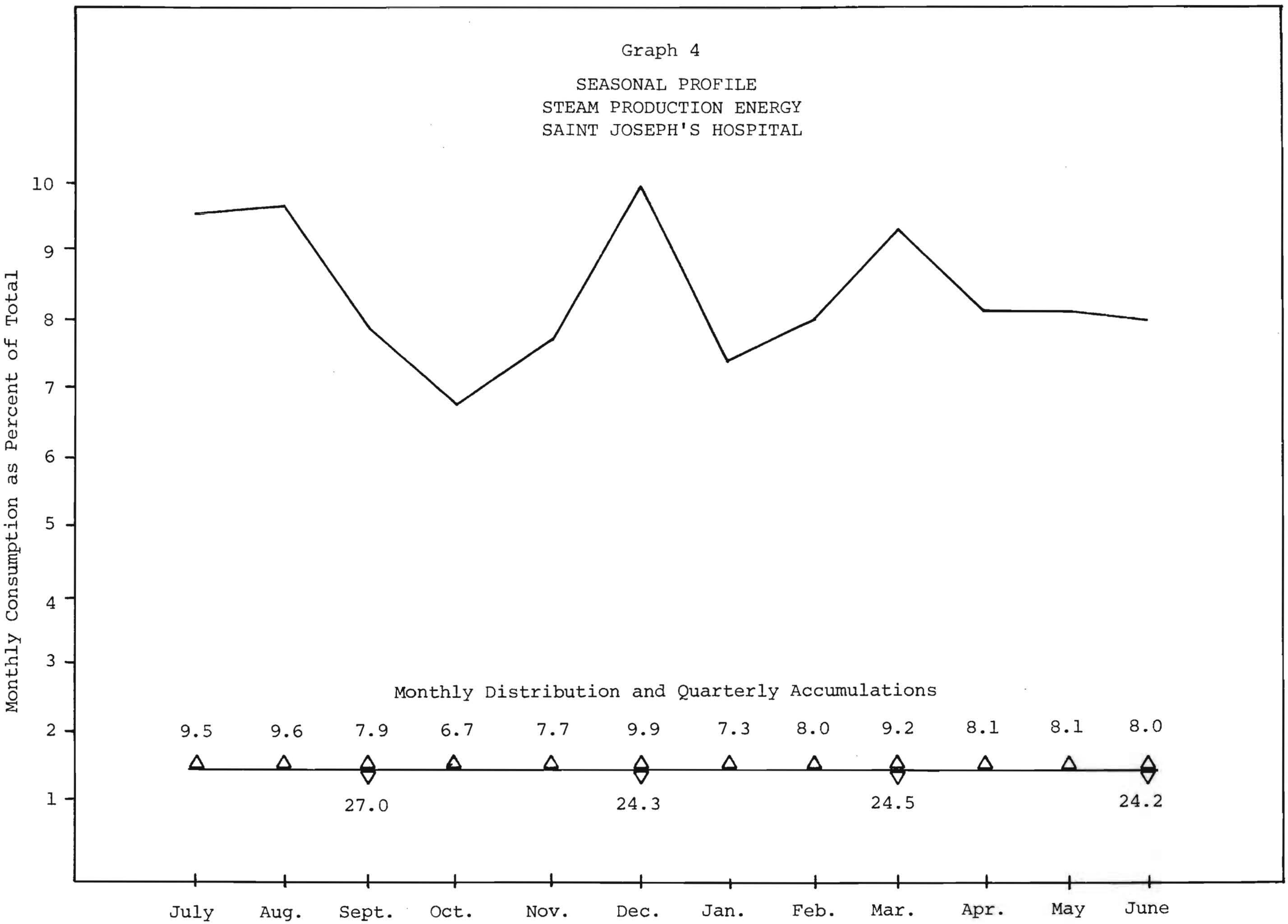
Table 3 illustrates these increases through annual summaries over the audit period. A 1% to 2% increase per year, as shown in the summary, is not substantial, but as the cost of energy increases the hospital will have to also closely manage firm natural gas.

Table 3

SUMMARY OF FIRM NATURAL GAS CONSUMPTION AND COSTS1/

Year	Million BTU	% Change from Preceding Year	Actual Cost1/
1972-1973	514	-	$ 514
1973-1974	610	+1	810
1974-1975	762	+1	962
1975-1976	916	+1	1,353
1976-1977	1,708	+2	2,550

1/ Rounded to nearest dollar.


Graph 4
SEASONAL PROFILE
STEAM PRODUCTION ENERGY
SAINT JOSEPH'S HOSPITAL
Monthly Consumption as Percent of Total
Monthly Distribution and Quarterly Accumulations
9.5
9.6
7.9
6.7
7.7
9.9
7.3
8.0
9.2
8.1
8.1
8.0
27.0
24.3
24.5
24.2
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June

During this past year, the greatest increase in firm gas usage and cost was experienced. The cost for firm gas in 1976-1977 almost doubled over the previous year. This was due both to increased consumption and escalating prices for firm gas per million BTU. As energy prices continue to rise, the hospital must make efforts to stabilize their firm gas usage to minimum levels. This will require better scheduling of the laboratory, kitchen, and incinerator operations which greatly affect the amount of firm gas used.

Total Hospital Energy

The final step in the audit analysis was to determine the average total million BTU energy consumption for the hospital. To do this, all energy forms were converted to million BTU and plotted monthly from July 1972 to July 1977. The results of this are shown in Graph 6. Monthly totals for the cost of all energies were also calculated and included in Graph 6. These plots illustrate the interesting phenomena of decreasing total energy usage in the hospital and steadily increasing costs.

As discussed in the individual energy sections, the average 1977-1978 costs for all energies reflect sharp increases. This can only mean that even with decreased consumption, the cost of energy for Saint Joseph's will continue to rise. The impetus to conserve energy in order to achieve the greatest operating efficiency is evident from these results.

In addition to the trends shown in Graph 6, Table 4 emphasizes the increase in energy costs on an annual basis. Since 1972, these costs have tripled while consumption has stayed almost constant and slightly decreased the last two years, even after additional space was occupied in January 1976. This slight decrease was a result of energy conservation measures the hospital implemented during 1975, 1976, and 1977. With this excellent start towards decreased consumption, both the hospital administration and staff are prepared to continue energy conservation efforts and to implement a long-term program.

After careful analysis of the audit data, the basic energy year was calculated using the average of 1975-1976 and 1976-1977 energy data. These years were used because they reflected (1) attempts to conserve energy since 1975 and (2) decreases in actual consumption for the two major energy types, interruptible natural gas and electricity. Table 5 shows the million BTU consumption

Table 4

SUMMARY OF TOTAL HOSPITAL ENERGY CONSUMPTION AND COSTS 1/

Year	Total Million BTU	% Change Over Preceding Year	Total Actual Cost 2/
1972-1973	100,495	-	$135,190
1973-1974	113,089	+12	199,355
1974-1975	116,804	+ 3	285,511
1975-1976	85,804	-28	271,083
1976-1977	93,823	+ 9	342,482

1/ Consumption and cost figures reflect estimates for unavailable data.

2/ Rounded to nearest dollar.

for the individual energy types, their average rates based on 1977-1978 dollars and the total estimated cost by type.

The total energy usage at the hospital is estimated at 89,822 million BTU annually at a cost of $377,361. The energy consumption and cost reduction estimates resulting from the conservation recommendations were calculated from the basic energy year figures. These savings were presented in the Executive Summary.

Table 5

SUMMARY OF THE BASIC ENERGY YEAR

	Million BTU	Unit Cost	Total Cost
Electricity	24,356	$0.035/KWH 1/	$249,770
Interruptible Natural Gas	64,151	1.81/mil. BTU	98,410
Fuel Oil	9,782	.38/gal.	2,630
Firm Natural Gas	1,315	2.00/mil. BTU	26,551

1/ Reflects September 1977 rate increase from Savannah Electric and Power Company.

III. ENERGY MANAGEMENT PROGRAM

Energy management will continue to play an important role in hospital management as energy costs continue to climb and demand an increasing share of Saint Joseph's operating budget. Experience has shown that energy conservation efforts will be sustained only if the entire hospital staff supports them. In addition, the hospital management must make a firm commitment to an energy conservation program. At Saint Joseph's, this management exists at essentially two levels. The first is the hospital board and hospital administrators responsible for establishing overall policy. The second level includes directors and department heads who provide staff direction and have operational authority. Diagram 1 illustrates the basic organizational pattern for energy management which can aid in implementation of a conservation program.

Diagram 1

ORGANIZING FOR ENERGY MANAGEMENT

Hospital Board and Administrator	Commitment	Level 1
	↓	
↓	Direction	
	↓	
Directors and Department Heads	Commitment	Level 2
	↓	
↓	Direction	
	↓	
Nurses, engineering and maintenance staff, custodians, maids, etc.	Commitment	
	↓	
	Implementation	

The key to a sound operational program as shown in Diagram 1 is the commitment to conservation at the policy level and effective communication of this commitment to all levels of staff. Clear direction also needs to be provided by both levels of management. Commitment and direction are essential to effective program implementation.

Energy Conservation Committee

A practical approach to maintaining commitment and cooperation throughout the hospital staff is to organize an energy conservation committee with representation from administration, engineering, the medical staff, and other selected departments. This committee forms a hospital-wide framework within which the details of program management and liaison for program implementation can be structured. However, the committee is not an end in itself, but serves as an aid to the hospital conservation program. Functions of the committee include:

- Assisting in the formation of energy policies and goals,
- Reviewing and evaluating new energy-saving ideas and operational modifications,
- Providing a feedback mechanism to and from the operating level, and
- Assisting in the evaluation of conservation programs and overall program efforts.

The committee should be active in all phases of the management program and be briefed monthly or quarterly. Each member of the committee could be responsible for a function in the program or a part of the hospital facility. They would be accountable for both implementation and control of the program at their respective level. This allows the committee to be an effective management tool and also a major link between the operational level and the administrator's office at the policy level. As in any management system, open communications and feedback are essentials for successful execution of a program and the energy conservation committee will help fill these requirements.

In practice, the Engineering Department personnel are principally responsible for the daily tasks associated with energy conservation. However, an active energy conservation committee is required to deal with the varied range of problems and considerations resulting from the program. For example, some staff members may not understand that conservation means sound management through the elimination of excessive or wasteful energy use, not energy curtailment. Many problems can be minimized if the staff is kept informed of program activities and progress. The staff should also be encouraged to contribute energy-saving ideas for their areas of operation or hospital-wide. Staff feedback should also be provided through the conservation committee.

Conservation Program Initiation

The responsibility for establishing the scope and magnitude of the conservation program lies with Saint Joseph's management. Although the majority of conservation recommendations must be implemented by personnel from the Engineering Department, they also will need assistance from the conservation committee and hospital administrators. Direction and support must be provided by these groups if the program is to be successful and effective.

Five basic steps are involved in initiating a conservation program as shown in Diagram 2.

Diagram 2

FIVE STEPS IN HOSPITAL ENERGY CONSERVATION

1. Survey of Hospital Facilities and Energy Audit	→	2. Analysis of System Operations and Procedures	→	3. Formulation of Energy Saving Ideas
		↑		
		Modify or Redirect as Required		↓
		↑		
		5. Program Management: Monitoring and Evaluation	←	4. Program Implementation

---

Of these five steps, the first three have been accomplished. The basic data have been developed, hospital systems have been studied and energy saving ideas developed. In initiating Step 4, the administrator should organize a team from the Engineering Department which will work with the conservation committee and consultants, if required, to implement the conservation recommendations. Step 5 naturally follows implementation. It requires continual updating of energy consumption data developed during the audit as described in the energy accounting system.

Energy Accounting System

The energy accounting system is the extension of the audit that was conducted to establish an historical energy base for Saint Joseph's. An essential element of the long-term management conservation program is a systematic compilation of energy consumption data for program monitoring and evaluation. We recommend that personnel in the Engineering Department be responsible for this task and continue to work with the Accounting Office so that copies of all utility bills are received for their own files.

Continuously recording energy data is a relatively simple task because it only involves logging data as they are received from utilities and fuel suppliers. It is suggested that all data be converted to million BTU when summarized so that total hospital energy used per month also can be plotted. The simplicity of this task should not be allowed to obscure its importance. These data generally comprise the sole method by which the impact of conservation efforts can be evaluated. This evaluation is used to determine how well modifications were made, if additional action in any specific area is necessary, and what energy planning needs are required in the near and long term. Data are also fundamental in the promotional programs necessary to encourage all hospital personnel, patients, and visitors to participate in the conservation efforts.

Consumption statistics derived from the utility summaries are useful for the following purposes.

1. Program Guidance. Annual energy program planning for the hospital can be accomplished using energy data. Budget requirements can be projected based on past trends and program emphasis can be defined. These data provide supporting material for all decisions made in the energy program from year to year.

2. Program Overview. Regular compilation and review of consumption data leads to the prompt identification of problems which may otherwise go undetected. For example, a sudden increase in electrical demand could indicate improper start-up sequencing of several major pieces of equipment. These data should be reviewed on a scheduled basis by the hospital administrators, energy committee members and engineering personnel.

3. Comparisons with Similar Hospitals. As energy conservation programs are initiated in other hospitals, a uniform accounting system will allow comparisons to be made to indicate the relative effectiveness of various conservation actions. Caution should be exercised when making comparisons, however, as each hospital is a fairly unique structure and age, type of construction, and other factors must be considered before valid comparisons can be made.

There are three forms included in this section that are recommended for logging consumption and cost data at Saint Joseph's. These data can then be directly plotted onto Graphs 1, 3, 5, and 6 so that trends in consumption and cost can be monitored. Plots of energy by type and total hospital energy should be prepared monthly to derive the annual trends in cost and consumption. An additional graph for continuing these yearly plots is included at the end of this section. As data are plotted by month on the annual trend graphs, percentage calculations of electrical and steam production energy usage should be compared to the seasonal trends in Graphs 2 and 4. This allows management to effect needed adjustments in consumption throughout the year.

All the energy data must eventually be converted to British Thermal Units (BTU) for calculation of the total hospital energy requirements. The most common usage today of BTU is million BTU. This terminology has been used throughout this report to describe each type of energy. Conversion to million BTU is also necessary to analyze energy consumed by multi-fueled boilers, which use both natural gas and fuel oil, such as the ones at Saint Joseph's. Conversion factors for various energy types to million BTU are listed for quick reference.

Electricity	KWH x 3,413 = million BTU
Natural Gas	CCF or Therms x .1 = million BTU
Fuel Oil	Gallons x 140,000 - No. 2 = million BTU
	146,000 - No. 6 = million BTU

Once this accounting system is implemented, comparisons with other hospitals as they initiate similar programs will be facilitated. This is done by dividing the hospital's total million BTU consumed by the total number of gross square feet of space heated and air conditioned. This number is the Energy Utilization Index (EUI) which is a common base for comparison.[1/] It should be

1/ Total Energy Management for Hospitals, Federal Department of Health Education and Welfare, Publication (HRA) 77-613.

noted, however, that as such comparisons are made in the future, they should be done with extreme care. Because of different utilization patterns, design, weather conditions and other factors, a building which is as energy efficient as it possibly can be could feasibly have an EUI higher than a building whose efficiency has not been optimized.

A description of the items found in the three energy accounting forms is presented for future use and reference in Saint Joseph's management program.

Year. The year for which the form is being prepared.

Month. Regardless of the billing date used by the electric or gas suppliers, energy units consumed should be extracted from the bill for the month in which the greatest number of days occurred. If the billing period is March 2-April 2, enter the usage under the month of March. Obviously, this technique can cause some inconsistencies. For example, the electric utility may use the March 2-April 2 method while the gas utility may use March 10-April 10. It is feasible -- through extra work -- to develop all data for a calendar month alone; the data extracted will be somewhat more exact.

Electricity (KWH). Enter total monthly kilowatt hour usage given on the electric bill.

Electricity Demand (KW). Enter both billed and actual demand given on the electric bill.

Electricity Total Cost (Dollars). Enter total net cost (no late payment penalty) given on the electric bill.

Electricity Cost per Unit (Dollar/KWH). Divide total net cost by total consumption (KWH). This value provides a quick check to determine billing errors and also provides cost escalation trends for electric energy. This value can even be plotted on a monthly basis if desired.

Electricity - Million BTU. The BTU (British Thermal Unit) is a measure of energy into which all other energy measures (kilowatt hours, gallons of oil, etc.) can be converted. The amount of million BTU represented by the amount of KWH shown is easily determined by multiplying the KWH amount by its appropriate conversion factor. The product is in million BTU and should be entered in this column.

Fuel Oil (Gallons). Enter amount of oil actually consumed during month. Normally this amount must be determined by measurements during the month and is not available on bills.

Fuel Oil Total Cost (Dollars). Multiply per gallon cost on latest bill by the amount of oil used during the month.

Fuel Oil Cost per Unit (Dollars/Gallon). Enter per gallon cost on latest bill. The trend in this unit cost can be graphed on a monthly basis.

Fuel Oil - Million BTU. Enter the million BTU equivalent for the type oil using the appropriate conversion factor provided at the bottom of the form.

Interruptible Natural Gas (CCF or Therms). Enter gas consumed in CCF (hundred cubic feet) or therms as given on bill.

Interruptible Natural Gas Total Cost (Dollars). Enter total net cost given on bill.

Interruptible Natural Gas Cost per Unit (Dollars/CCF or Therm). Divide total net cost by total gas consumed. Record as dollars per CCF or therm. This value can also be plotted monthly.

Interruptible Natural Gas - Million BTU. Multiply the figure in the space immediately to the left by the conversion factor provided and enter the product in this space.

Firm Natural Gas. Same values as interruptible natural gas.

Total Energy Cost per Month (Dollars). Add across all energy types for each month. Enter total for each month.

Total Energy per Year per Energy Type. Add amount used each month in each energy type. Record in appropriate commercial units.

Total Cost per Year per Energy Type (Dollars). Add monthly costs for each energy. Record for each energy type.

Total Energy Cost per Year (Dollars). Add monthly energy costs. Enter for the year.

Total Million BTU. Total BTU for the period is determined easily by adding together million BTU for the various other energy forms. This figure should be plotted on a monthly basis for a trend of total energy consumption.

Form 1

ENERGY ACCOUNTING FORM
SAINT JOSEPH'S HOSPITAL

Electricity ______ Fiscal Year

Month	KWH	Million BTU	Demand Actual	Demand Billed	Cost Total	Cost Per Unit
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
Total						

Conversion Factor (_____KWH x 3,413 = Million BTU)

Form 3

ENERGY ACCOUNTING FORM
SAINT JOSEPH'S HOSPITAL

Firm Natural Gas ____________ Fiscal Year

			Cost		Energy Totals	
Month	Quantity	Million BTU	Total	Per Unit	Million BTU	Cost
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
Total						

Conversion Factor (_____ CCF x .1 = _____ Million BTU)
(_____ Therms x .1 = _____ Million BTU)

IV. BUILDING THERMOGRAPHY

Georgia Tech has recently acquired an infrared imaging research instrument, which will develop into a valuable aid in energy conservation research work. The instrument can indicate excessive heat losses from walls, windows, roofs, and malfunctioning mechanical equipment.

In appearance the instrument resembles a portable television unit except that it "sees" infrared radiation rather than visible light rays. The unit works on the principle that all objects give off radiation at a frequency dependent on their temperature. At normal temperatures this radiation is in the invisible infrared range. The instrument records this radiation and displays the results on a television screen. A camera attachment records the displayed image.

On the evening of December 13, 1977, a series of 16 thermographs were taken of the exterior of Saint Joseph's. The team was accompanied by Mr. Fred de Borde. Two points should be kept in mind when viewing these pictures. The first is that these are not light image photographs of the hospital, but rather images that are formed by different surface temperatures with the lighter areas in the pictures being relatively warmer than the dark areas. Second, the team's skills of interpretation are not yet developed so that it is able to provide in-depth qualitative and quantitative analyses.

Photographs 1 and 2

These pictures are typical of several taken of the hospital windows. The windows are prominent in that glass has relatively little resistance to heat flow and their light color indicates that heat from the room is being transmitted through the windows. The fact of high heat loss through glass is well known, but in the low-cost energy era the economic penalty was not severe. Today's design standards call for windows of minimum size and the use of double panes.

Also prominent in these pictures is the heat loss through the aluminum frames. The outline of the frames can be seen above the insulated window panels. Aluminum, an excellent conductor of heat, readily transmits the heat from inside the room to the outside. Aluminum frames utilized in the future should be of two-piece construction with a thermal break between the two halves.

Photographs 3 through 7

These pictures are of the louver foundation vents and indicate the heated air escaping from these vents. In the pictures the ground is across the lower level with first floor windows visible in the upper portion. Pictures 6 and 7 illustrate a special feature of the camera where a single temperature is highlighted. The loss from these louvers appears excessive, but this can not be quantified until recommended balancing procedures are completed. These photographs suggest that the maintained building static pressure is too high.

Photograph 8

This photograph is interesting from an energy standpoint in that it indicates the walls of the penthouse to be considerably warmer than expected. At this time the reason for this is not known.

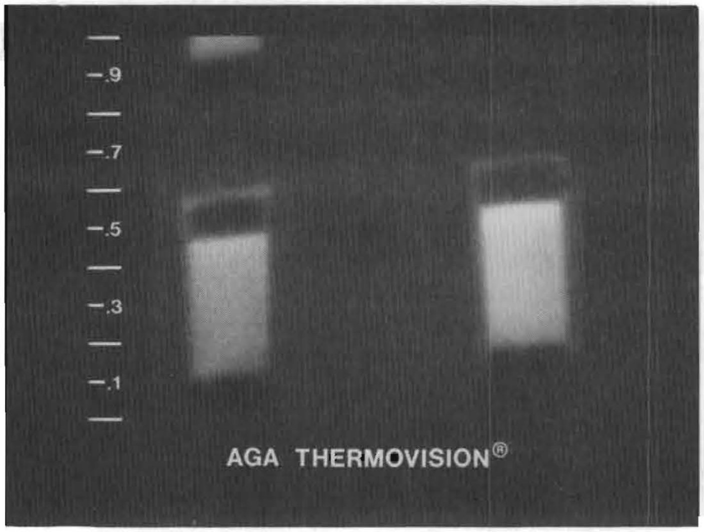
Photograph 9

This photograph illustrates the relative greater heat loss through the brick exterior walls as compared to the insulated panels in the window frames. The hospital's brick wall construction is of good design but this photograph depicts the need for walls in the future to be designed with increased thermal resistance.

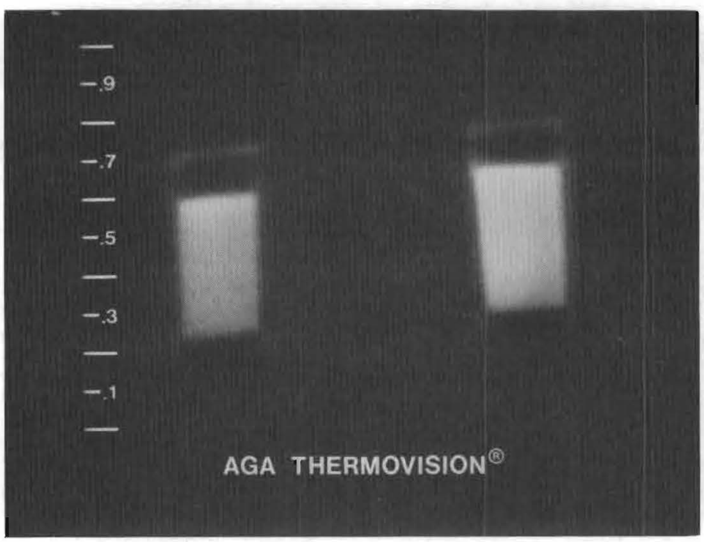
Photographs 10 through 16

No particular comments are made concerning these pictures as they duplicate others already discussed.

THERMOGRAPHS

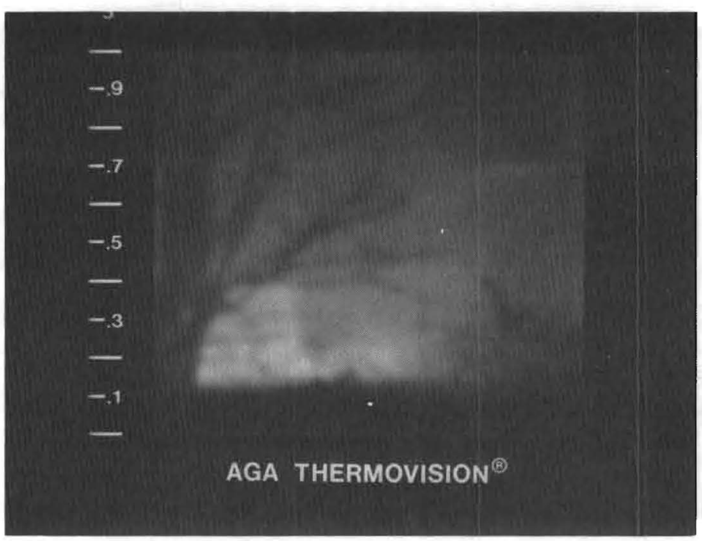


Thermograph 1

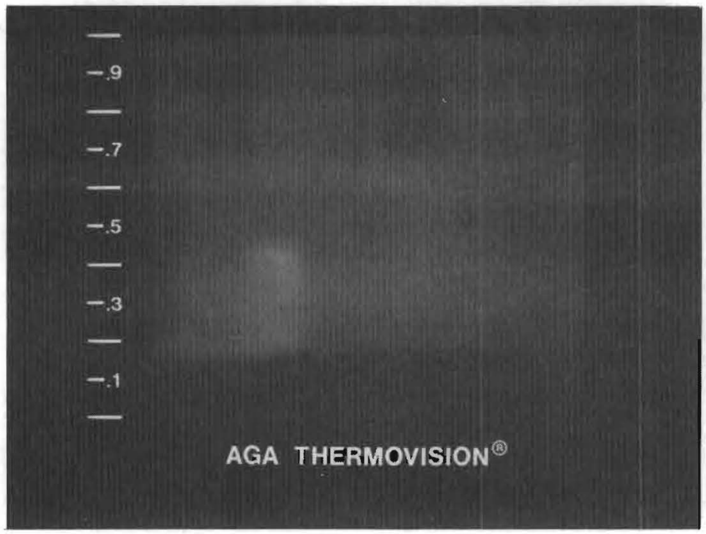


Thermograph 2

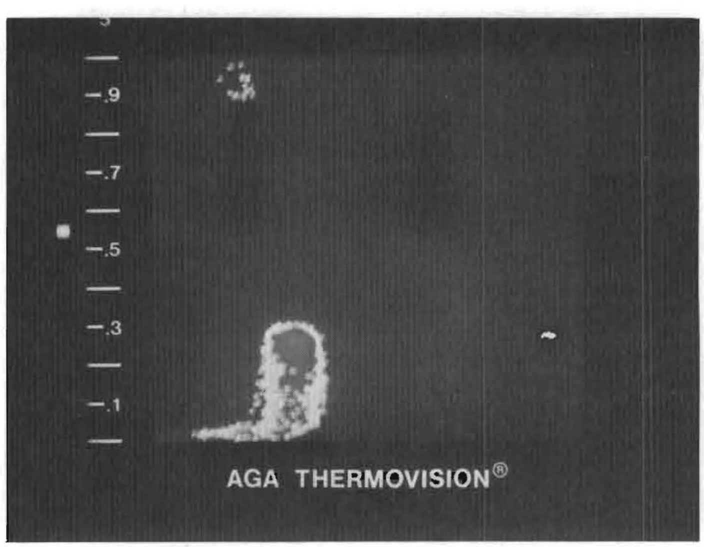
Thermograph 3



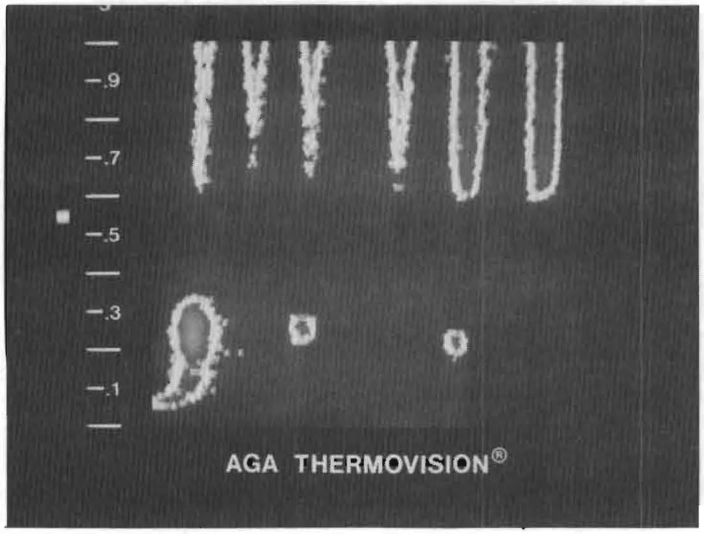
Thermograph 4



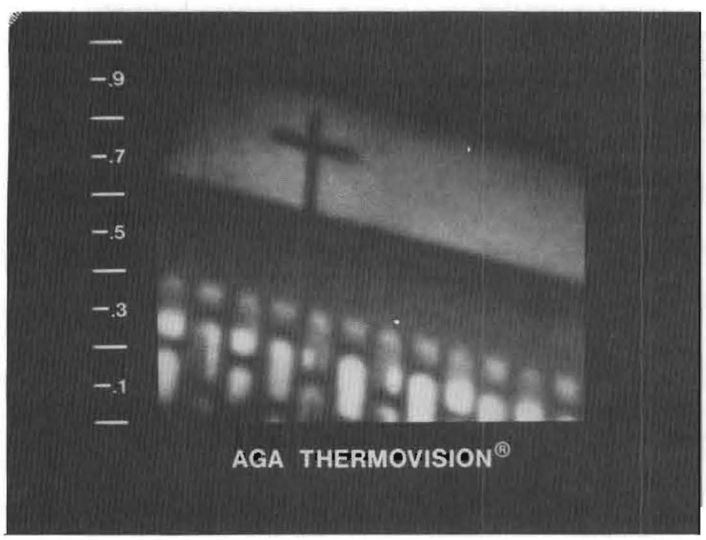
Thermograph 5



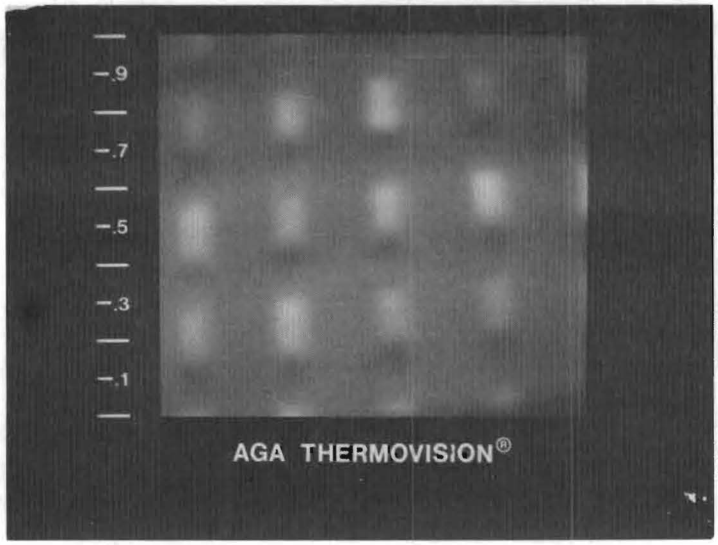
Thermograph 6



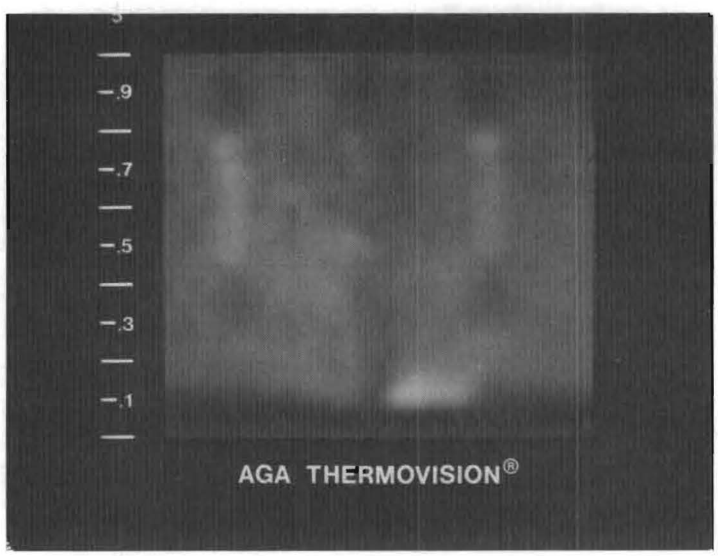
Thermograph 7



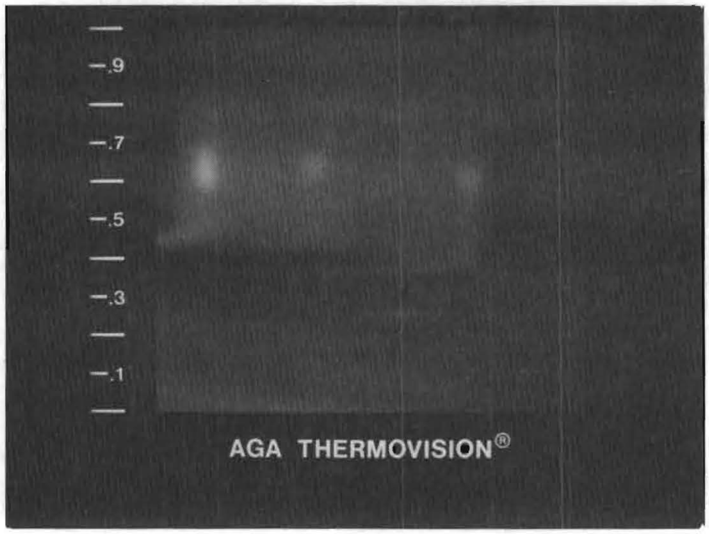
Thermograph 8



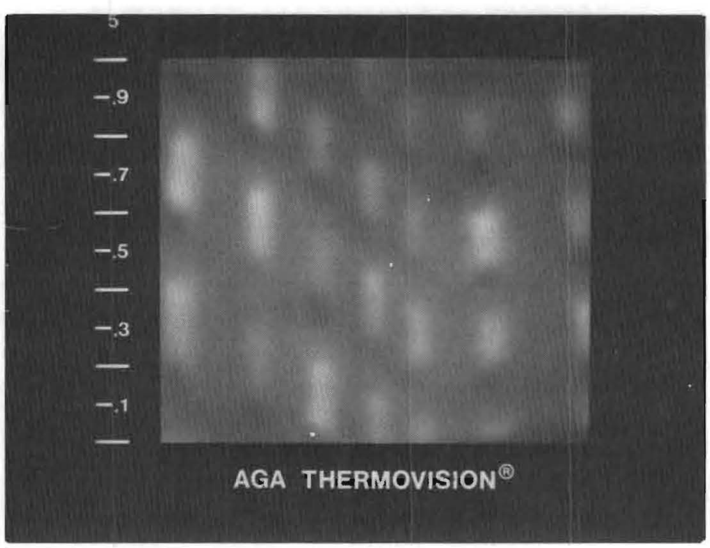
Thermograph 9



Thermograph 10

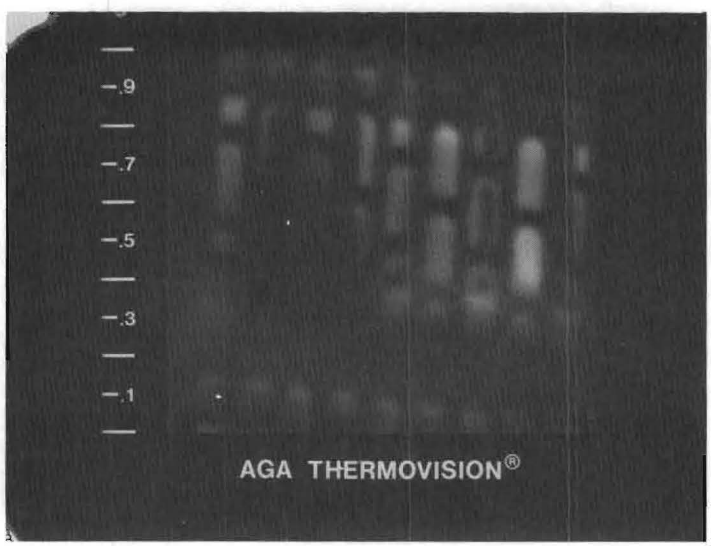


Thermograph 11

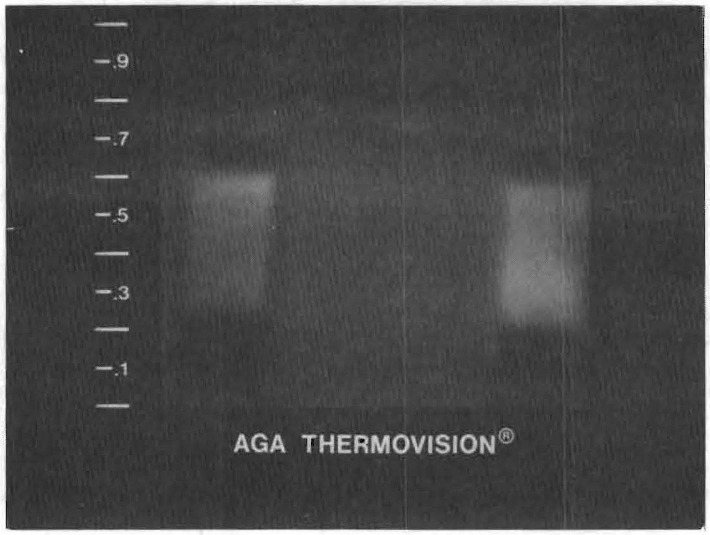


Thermograph 12

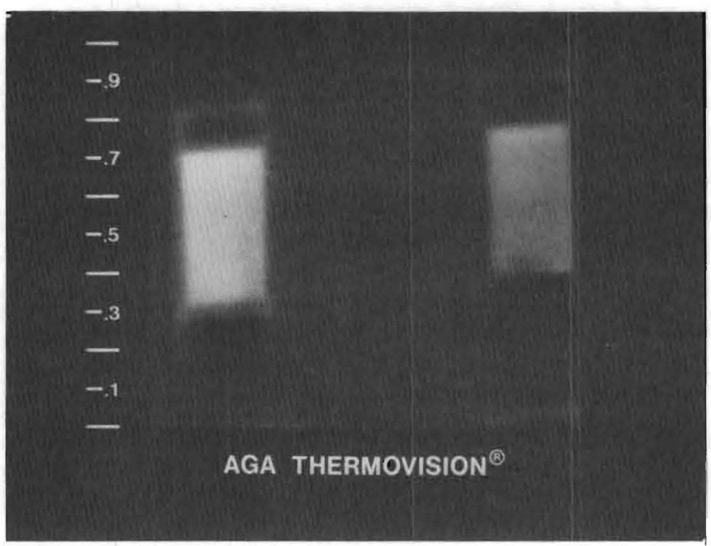
Thermograph 13



Thermograph 14



Thermograph 15



Thermograph 16

V. ENERGY CONSERVATION PROGRAM

Ten recommendations for saving energy were developed for the Saint Joseph's energy conservation program. These recommendations are a result of (1) the facility observations and equipment tests made during the hospital surveys, (2) the energy usage trends analyzed in the audit, (3) discussions with hospital personnel, and (4) past experiences with successful conservation measures by the energy team. Realistically, not all of the recommendations can be implemented at one time. The recommendations must be studied, ranked as to priority, and integrated with other existing and proposed administrative programs at Saint Joseph's. Of course, only when all the recommendations have been implemented will the cost savings and optimum energy usage levels be attained. However, the trend in energy usage for the hospital will begin to move downward as efforts are made to implement selected conservation actions. The recommendations for the Saint Joseph's energy conservation program include such areas as:

1. Central Chilled Water System
2. Conditioned Air Quantities
3. Boiler Operations
4. Hot Water Service
5. Boiler Feedwater Tank Insulation
6. Roof Insulation
7. Window Treatment
8. Air Conditioning Load Reset
9. Laundry
10. Lighting Reductions

It is also suggested that Saint Joseph's obtain a copy of Total Energy Management for Hospitals, a recent publication from the Federal Department of Health Education and Welfare which contains some general energy conservation guidelines for hospitals. Many of the ideas presented in this handbook have already been implemented by Saint Joseph's, but it is a good reference source.

Central Chilled Water System

The building's air conditioning system operates on chilled water supplied by two chilled water machines located in the mechanical room. One of the machines is electrically driven and the other is an absorption-type unit which is operated on steam supplied by the steam boilers, also located in the mechanical room.

The specifications for the machines are:

Electric Centrifugal

Manufacturer - Carrier Corp.

Model No. 19DA-325
19DA-35-204

Serial No. 6747 12027

Refrigerant - R-11

Rating - 325 tons

Evaporator - 1,740 gallons per minute
- 48.5°F - 44°F
- 1 pass cooler
- 10-foot pressure drop

Condenser Water - 940 G.P.M.
- 85°F - 95°F
- 2 pass condenser
- 19-foot pressure drop

Suction Temperature - 31°F

Condensing Temperature - 107.9°F

Power - 460 V - 3 ph - 60 cy

Full Load Amps. - 357

Standard Inrush Amps. - 623

Locked Rotor Amps. - 1945

Motor - C8 - 257 K.W.

Absorption Machine

Manufacturer - Carrier

Model No. 16JA 036-604

Serial No. 6804 4825

Nominal Rating - 365 tons

Evaporator - Single pass
- 19.5-foot pressure drop
- 1,300 G.P.M.
- 53.6°F to 46.9°F

Condenser - 1,200 G.P.M.
- 85°F to 103°F

The operating practices associated with these chilled water machines offer a number of substantial energy conservation opportunities.

One Machine Operation. Typically, the cost for providing a unit of cooling from a central chilled water plant is lowest when the machine is fully loaded; that is, when the plant is operating at maximum design conditions. In practice, a central plant system operates at 100% capacity only a small percentage of the time during the year. On a year-round basis, a central plant typically operates on an average of 30% to 35%, as does the central chilling plant at Saint Joseph's. From the operating data taken during this study, it appears that one machine should be able to handle the hospital's cooling load during all but the summer months. The team recommends, therefore, to have only one machine in operation as long as it will carry the air conditioning load. In discussing this recommendation, Mr. Tommy White pointed out that leaks in the hospital's electric centrifugal unit caused operational problems if the machine was down more than a few days. Machines of this type should be leak tight to the degree that a six-week to two-month shutdown would cause no start-up problems. Leaking machines can also experience increased internal corrosion. This problem should be discussed with the manufacturer and corrective steps taken.

Chilled Water Pumps. The central chilling system is equipped with two pumps to circulate the chilled water throughout the hospital to the various air conditioning units. Each of these pumps is equipped with a 50-horsepower electric motor. From tests that were run, it appears that one pump has sufficent capacity to handle the water distribution requirements when only one chiller is in operation. At the hospital's current electrical cost, the energy consumed by a 50-horsepower motor would amount to $1,004 per month. It is, therefore, the team's recommendation that when one chiller is on-line, then only one chilled water circulating pump be operated.

Supply Chilled Water Temperature. Standard air conditioning chiller design calls for the chilled water to be supplied to the building at a temperature of 42°F to 45°F. As will be noted in the specifications, the Saint Joseph's design is 44°F. This water goes to the various air conditioning coils throughout the building where it is heated some 10°F, then returns to the chillers where it is recooled. Tests have proven that in milder weather the temperature of the leaving water from the chiller can be raised from 3°F to 5°F and still provide proper air conditioning to the building. The importance of this fact is that for every degree that the leaving water can be raised in temperature, the efficiency with which the chiller operates is increased by 1½%. Stated another way, if the chiller leaving temperature can be raised 5°F, it will require 7½% less electricity to do the same cooling.

Presently, chiller control cannot be automated. Each building must have test runs made to determine its system's particular operational characteristics. The test procedure is simple. The leaving water temperature control is adjusted to some higher degree and the building is monitored to see if comfortable conditions are maintained.

This technique is now practiced at the Georgia Tech central cooling plant. The operator obtains the predicted high temperature for that day and then sets the leaving water at the point which experience has taught will provide satisfactory cooling. Calculations indicate this technique has reduced the campus cooling cost by an overall amount of 6%.

Condenser Water Control. Prevailing practice controls the condenser water to the chiller (water returned from the cooling tower) with by-pass valves set at 85°F. Tests show that in mild weather lower temperatures are obtainable, and most chillers will operate with condenser temperatures down to 60°F. The energy conservation interest in lowering the condenser water temperature is that chillers will operate at about 1½% increased efficiency for each degree the condenser water temperature is lowered. For example, if the chiller can be supplied with 60°F condenser water instead of 85°F condenser water, the chiller will produce the same amount of cooling with 37½% less energy.

As opposed to the simple adjusting of one control to set the chilled water leaving temperature, discussed in the prior section, the resetting of the condenser water temperature has several complicating factors. These can be handled automatically by the installation of proper controls. The design of the proper control system must be performed by a consulting mechanical engineer in accord with the recommendations of the chiller manufacturer. One word of caution -- the absorption chiller may not be amenable to condenser water reset.

As there are many variables, it is difficult to predict the exact savings obtainable from a condenser water temperature control system. One computer study indicates that for a system of Saint Joseph's size, savings of over $3,000 per year are obtainable.

Evaporator Chilled Water Flow Rates. The chilled water piping connecting the electric centrifugal and absorption machines is somewhat unusual. Our study indicates that while the piping presents no operational problems, it does result in higher energy cost and, therefore, should be investigated for possible revision.

The absorption machine and the electrical machine are basically connected in series with the absorption unit being the upstream machine. The water to be chilled first passes through the absorption unit and then through the electric unit. From the specifications given at the beginning of this section, the water enters the absorption unit at 53.6°F and leaves at 46.9°F, and enters the centrifugal machine at 48.5°F and leaves at 44°F. As the machines operate in series, it would be expected that the leaving water temperature at the absorption unit would be the entering water temperature of the centrifugal unit. Notice the specifications call for leaving the absorption unit at 46.9°F while the entering temperature for the centrifugal machine is given at 48.5°F. This rise in temperature is caused by the bypassing of 440 gallons of water around the absorption unit and introducing this bypassed water directly ahead of the centrifugal unit. This bypassing of water is indicated by the specified flow rate at 1,300 gallons per minute for the absorption unit and 1,740 gallons per minute for the centrifugal unit. It is the team's opinion that this bypassing imposes a 2.4% increase in energy cost.

Not knowing the considerations that resulted in this design, it could have been evaporator water pressure losses. In any event, the system was designed when operating costs were low. Since the possible energy savings are so significant, the team recommends that the design be reevaluated.

Conditioned Air Quantities

In the operation of large air conditioning systems, the energy required by the blowers to circulate the conditioned air throughout the building is very significant. To find that the blower energy exceeds the energy required for the actual heating and cooling of the air is not unusual.

As the energy required for blower operation is so important, an energy conservation program must address the problem of establishing the minimum air quantity required for the building to be air conditioned properly. Another way to state the significance of establishing the correct air quantity is to note that the horsepower required to move a quantity of air through a given system is proportional to the square of the air quantity. In other words, if the air quantity being circulated is twice the required amount, the horsepower requirements are increased four times.

Fan horsepower requirements are established initially by the design engineer following a series of calculations including heat loss, heat gain, and duct design system pressure drops. Calculations of this type include many assumptions; therefore, it is unusual when the installed system air quantities exactly match the building requirements. Experience indicates that most systems, as installed, circulate more air than required. In several buildings on the Georgia Tech campus, tests have shown that air quantities could be reduced. The reductions averaged 25%. A reduction of 25% in air quantity reduced the electrical energy requirement by over 40%.

The best technique for determining the correct minimum air quantity required is simply to test the system with lower air flow. Namely, the fan speed is decreased by some arbitrary amount and the system is operated to see if it is satisfactory. The quantity of air circulated is in direct proportion to the speed of the fan. For example, a test could be performed to see if the system will operate at a 25% reduction with the fan turning at 600 rpm. A 25% reduction of 600 rpm is 450 rpm. The belts and pulleys on the blower and blower motor are changed to give 450 rpm. The system is then operated to see the results. Generally, the electric motor does not have to be changed as a motor will only draw enough energy (electricity) to carry the load connected to it.

One technique for checking to see if the air quantity can be reduced without the expense of changing the pulleys and belts initially is to secure a heavy piece of plywood over a percentage of the fan inlet. The percentage of the fan inlet covered is increased to the point where the air quantity is the minimum for satisfactory operation. The air quantity flowing is measured prior to beginning the experiment and after the inlet is closed to the minimum satisfactory level. This percentage reduction is then used to reduce the fan speed by the same percentage.

The process of determining and setting the correct air quantity is not simple, but it has proven to be very effective in many cases. Some Georgia Tech buildings are now operating with a reduction in energy requirement of 25%, simply by reducing the air quantity to the minimum required amount. These savings are being recognized and many new buildings are going to variable systems to take advantage of this energy reduction.

Boiler Operations

The economical operation of steam boilers involves four areas:

a. Combustion Efficiency

b. Water Scale Control

c. Fireside Tube Cleaning

d. Matching Boiler Operation to Load

At Saint Joseph's, the boilers are maintained and operated at such a high level that the team considered omitting these comments other than to say "well done." However, for the purpose of "administration education" brief comments are included. The area that the team emphasizes is the last one listed.

Combustion Efficiency. In the combustion process for any fuel, there is a definite requirement for a certain quantity of air for a given quantity of fuel. If too little air is supplied, there is insufficient oxygen for complete combustion, which results in wasted fuel. If excess air over requirements is supplied, the excess will not contribute to combustion, but is passed out the chimney as wasted hot air. In the past, most boilers were adjusted by "eye"; that is, by just looking at the flame. Such estimating frequently resulted in a loss in efficiency of about 5%.

The correct way to set boiler combustion is with test instruments which measure the amount of carbon dioxide in the exhaust gas and its temperature. As these instruments are relatively inexpensive ($100) and easy to use, the team recommends that they be purchased and put into use.

One widely used brand of these combustion test instruments is the Fyrite Test Kit, containing one CO_2 indicator and one stack thermometer. Fyrite is manufactured by Bacharach Instrument Company. These test kits are available from a number of wholesale supply companies.

Water Scale Control. The boiler surfaces that are in contact with water can form scale deposits unless careful attention is given to proper water treatment. These scale deposits will materially shorten the life of the boiler and inhibit heat transfer. With scale on boiler tubes, the heat cannot pass as readily into the water, and the result is loss in boiler efficiency and increased fuel cost.

A chemical boiler water treatment program is a part of all well-managed power plant operating programs, and it is recommended that one be established.

Fireside Tube Cleaning. Cleaning the boiler heating surfaces is seldom necessary because the burning of natural gas is usually a clean process. The opposite is true when oil is the fuel. While oil can be burned very cleanly, some soot will almost certainly be formed and collect on the boiler heating surfaces. When soot is present, a loss in boiler efficiency occurs with an increase in fuel cost. For example, a layer of soot 1/8-inch thick will reduce the boiler efficiency by approximately 9%. The boiler operating program should, therefore, include a monthly inspection of the boiler tubes and other heating surfaces. A boiler stack thermometer is a good instrument for detecting the formation of soot, which causes an increase in the exhaust temperature. Any soot found should be brushed and vacuumed away.

Matching Boiler Operations to Load. The hospital receives steam from three boilers. Two of these boilers were installed originally and the third added at the last building addition. These boilers are rated as follows:

Boilers No. 1 and No. 2	Boiler No. 3
Continental	Cleaver Brook
Model No. 13802	Model CB 200 HP
Rated Output - 10,043 M BTU/hour	Rated Output - 6,695 M BTU/hour

The fuel consumption of these boilers can be directly measured from the interruptible natural gas meter, as all of this gas is fed directly to the boilers. All other natural gas requirements of the hospital, including the kitchen, incinerator, and laboratories, are supplied from the firm gas meter. Also, it should be noted that all of the hospital's use of No. 2 fuel oil is for the steam boilers.

The actual steam load on the boilers is primarily dependent on the outdoor temperature and the consumption by the absorption air conditioning machine. A viewing of several months of gas consumption taken from the gas company's meter charts indicates that the load could be carried, in most instances, with two boilers and frequently with only one boiler. The significance is that a considerable amount of energy is used in keeping a boiler hot and on-line. For example, on the tests conducted on December 14-16, 1977, during which the absorption chiller was secured, it appears that of the total energy used on a 24-hour basis, most of the energy used was required to keep the second boiler hot. This statement is based on team judgment, as the various end energy uses were not metered. In any event, a significant amount of energy is used for heating the second boiler.

The team recognized that factors other than energy affect the decision concerning the number of boilers to be kept on-line. However, the purpose is to point out from an energy standpoint the value in only operating as many boilers as are necessary to meet the load.

Hot Water Service

Hot water is supplied to the hospital from two systems located in the service building. One system generates and provides storage of 120°F hot water and the other serves water requirement of 180°F. The specifications for the hot water generators are:

Temperature	Capacity (gallons)	Recovery (gallons/hour)
No. 1 - 120°F	4,310	2,200
No. 2 - 120°F	4,310	2,200
No. 3 - 180°F	4,310	1,360

In connection with a solar energy proposal, a separate water meter was installed to measure the quantity of 120°F hot water used on an hourly basis. In examining several months' data, the team noted that the maximum hourly use recorded was 1,000 gallons and the typical maximum use was less than 800 gallons per hour.

As listed, the 120°F hot water system has two generators, each with a storage capacity of 4,310 gallons and a recovery rate of 2,200 gallons per hour. A comparison of this generator storage capacity with the actual consumption data shows that operating only one of the generator units more than meets the hospital's requirements at this time. To save the heat loss associated with keeping both generators in use, it is recommended that a trial test be conducted, utilizing just one 120°F hot water generator. The team expects that one unit will more than meet the hospital's present requirements.

Boiler Feedwater Tank Insulation

As a general statement, the hospital's pipe and equipment insulation is well installed and maintained. The one piece of equipment which should be insulated is the boiler feedwater tank located near the boilers in the service building. This is a 610-gallon, 48-inch diameter by 84-inch long tank which supplies return and makeup water to the boilers. This tank is presently uninsulated and since it contains water at over 200°F, considerable heat is lost. The team, therefore, recommends that this tank be insulated.

Roof Insulation

The roof construction for the hospital consists of:

1. Built-up roof
2. Two-inch rigid insulation board (two to one-inch layers)
3. Vapor barrier
4. Concrete
5. Air space
6. Suspended acoustical ceiling (5/8-inch minimum)

A roof of this composition has an overall resistance to heat flow of approximately R = 10.2. Today's design standards indicate that the R value should equal 20 or more. By adding a four-inch thick blanket of glass fiber insulation on top of the suspended acoustical ceiling, the R value of the roof structure would be increased to an approximate value of 22. The team, therefore, recommends that roof insulation be given consideration.

Window Treatment

As discussed in the Thermograph Section, the hospital's single pane windows with their aluminum frames are a source of significant energy loss. Today, for new construction, an architect would probably recommend frames with a thermal break and double glazing, plus possibly special heat reflecting glass or shading.

For Saint Joseph's present window system though, the team does not know of a specific improvement which is well designed and cost effective. Much work is in progress in this area and, hopefully in the future, designs will be developed and tested which are suitable and cost effective. The team will keep the hospital's needs in mind and will recommend a system if a suitable one becomes available.

Air Conditioning Load Reset

As discussed in other sections of this report, many poor energy practices came into use with the development of large central air conditioning systems such as the systems serving Saint Joseph's. With the current energy conservation emphasis, many of these inefficiencies have been identified and corrective strategies developed. Some of these areas are addressed in this report such as chillers, boilers, pumps, and air quantities. Another area in which significant reductions in energy usage have been accomplished is in the air conditioning control system. Control system manufacturers provide designs which maintain good environmental control under extreme conditions. But as has been discussed, extreme conditions occur only a small percentage of the time during the year. In one sense, it is comparable to controlling an automobile with a throttle that has only two positions -- open or closed. The control manufacturers are now developing systems which include control logic to overcome these problems and they result in sharply lower energy costs. The key word for this concept is "load reset."

Manufacturers are at various stages in their work of providing load reset concepts for existing control systems. Some existing systems are readily adaptable, while others are difficult to implement. At this time, the only practical way for an owner to learn the possibilities for his system is to contact the control manufacturer and Saint Joseph's should make this contact.

Laundry

As typical of laundries in general, the laundry at Saint Joseph's uses large quantities of steam and hot water. Laundry equipment manufacturers are aware of the energy intensive nature of their equipment and all are now developing new designs which are more efficient.

One technique coming into use is the recovery of the heat from the wastewater to preheat the incoming water. At this time, it appears economically practical to recover 40% of this heat, and the team recommends that the hospital consider this possibility. The amount of heat available and the ease of recoverability varies with specific laundry equipment, so it is necessary to obtain quotations on an installation directly from the manufacturer.

Beyond equipment changes, there are substantial energy savings available in equipment operation by proper scheduling. The laundry scheduling should be examined and only that equipment necessary should be operated. Temperatures, water quantities, and cycles should all be set at the minimum required to accomplish the cleaning. After hours, all equipment and exhaust fans should be secured.

The heat and humidity in the laundry area is excessive, which, undoubtedly, affects employees' performance. Attempts to ameliorate this situation using high ventilation rates or exhaust fans should be explored. The team proposes that consideration be given to utilizing some of the necessary exhaust air from the hospital's air conditioning system. Possibly, the connecting corridor could be used. In any event, an air conditioning design engineer would need to look at the hospital's air balance to determine feasibility.

Lighting Reductions

Essentially there are three approaches to save lighting energy, which include:

- o Reducing lighting levels where practical,
- o Turning off lights where possible, and
- o Upgrading efficiency of existing light fixtures.

Lighting levels should be reduced, where possible, to conform with the recently developed standards shown in Figure 3. These recommendations are not intended to apply to critical task areas such as operating rooms and some laboratory functions.

A lighting level reduction program can be accomplished with engineering personnel equipped with relatively inexpensive light meters and utilizing the lighting levels recommended in Figure 3 and the Illuminating Engineering Society Handbook standards for hospitals summarized in Appendix A. The hospital lighting survey indicated a number of areas where lighting levels can be reduced to save energy and to meet the recommended standards. Various methods to accomplish this are:

- o Replace with lower intensity lamps (lower wattage lamps are available for use with existing ballasts -- Saint Joseph's is currently using some watt saver bulbs throughout the hospital).
- o Remove lamps from multi-lamp fixtures and disconnect unused ballast.
- o Replace present fixtures with lower intensity fixtures or luminaries.
- o Curtail artifical lighting to take advantage of natural lighting whenever possible.

Since 1976, Saint Joseph's has reduced lighting levels by using many of the above methods. Watt savers have been used in some fixtures throughout the hospital and in the corridors; four-bulb fluorescent fixtures are burning only two lights. Efforts have been made to experiment with lower wattage incandescent lighting in various areas, and these lower levels have been accepted without any complaints about lower lighting levels. There are, however, a number of areas in which even lower lighting levels can save more electricity.

Corridors. The hospital corridors, in general, had fixtures burning only two bulbs in a four-bulb fixture. Even at these levels, the illumination can be reduced 35% to 66% and meet the suggested standards. This can be accomplished in a number of ways. The first is to use only the emergency lighting in the daytime. At night, only the emergency lighting is used and these levels are more than adequate. Another way to reduce the lighting is to disconnect all bulbs and ballast in selected fixtures along the corridors to get a more

Figure 3

RECOMMENDED LIGHTING LEVELS

Area	Foot Candles
Medical and Dental Facilities:1/	
Anesthesia and Preparation Room	30
Central Sterile Supply	30
Fracture Rooms	50
Nurseries	30
Sewing Room	30
Exits, at Floor	5
Corridors and Stairway	20
Auditoriums	20
Cafeterias	25
Computer Rooms	50
Conference Rooms	30
Janitors' Closets and Storage Rooms	5
Kitchens	70
Lobbies and Lounges	15
Mechanical Rooms	15
Toilets	20
Office Areas, Administrative Spaces, Instructional Areas:2/	
Work Station	50
Work Areas	30
Halls and Corridors	10
Prolonged Difficult Tasks (Accounting)	75

1/ Technical Guidelines for Energy Conservation in New Buildings, Naval Facilities Engineering Command, January 1975, pp. 7-3 and 7.4.

2/ Lighting and Thermal Operations, Energy Management Action Program for Commercial - Public - Industrial Buildings - Guidelines - FEA, Office of Conservation and Environment, Washington, D. C. 20461.

Note: Reference should also be made to Illuminating Engineering Society Handbook, 5th Edition, 345 East 475th Street, New York, New York 10017, 1975.

uniform lighting level. This method, of course, requires some experimentation to retain the desired effect of lighting throughout the corridor. Finally, "watt saver" fluorescent fixtures could be used if two lamp fixtures are required to meet hospital objectives. Although these lamps will not provide the same degree of savings as burning fewer lamps, they do burn at least 12% less light output and require 14% less energy than standard lamps. These lamps can be used throughout the hospital where higher levels are required to effect energy savings.

Mechanical Room. The lighting in the mechanical room consists mainly of two-bulb section fluorescent lighting. These lights were found to be on both day and night. During the day, natural lighting should be used when possible. It is estimated that a 50% to 70% reduction in lighting is available in the mechanical room. This can be accomplished with phantom or dummy tubes which are now commercially available. These tubes can be used in two-tube series fixtures where only one bulb is needed to meet the illumination standard.

Laboratories. The laboratories contain some critical task areas that will need to be illuminated at a constant level at all times. This can be done in some cases through specific task lighting. In the larger laboratory areas, lighting levels met recommended standards and specific task lighting was noted for detailed work. In rooms off the main laboratory areas, lighting levels were very high and many of these areas were unoccupied. Potential reductions of from 50% to 60% can be realized in these areas by removing bulbs from four-bulb fixtures and securing lights when the areas are not in use.

Administrative Areas. Administrative areas throughout the hospital had, in general, rather high lighting levels. In some work areas only emergency lighting was on in hallways, and offices used natural light when feasible. These examples should be further encouraged in other administrative areas. To successfully accomplish reduced overhead lighting, the hospital may need to provide individualized task lighting for general close-up work; additional receptacles may also be needed. Some areas such as the nurses stations already have individualized fluorescent light over work areas which, in addition to reduced overhead lighting, will meet the standards.

Waiting Areas. In general, lighting in the waiting areas can be reduced. Security lighting in the main lobby area would be sufficient for daytime use also. Lighting in waiting areas on patient floors should be secured after visiting hours. Also, since these areas are located adjacent to window space, natural light during daylight hours should be used whenever possible. Lighting levels in waiting areas such as admitting, X-ray, and the emergency room can also be reduced and still meet accepted standards.

These areas are those which can provide the most immediate electrical saving through reduced lighting levels. In addition to these specific areas, a hospital-wide campaign to turn off lights when not in use should be instituted. Efforts should be made especially during the day when there is a tendency to leave lights burning in unoccupied or unused rooms. Posters and switch plate covers, such as the one in Figure 4 have proved effective in sustaining such a campaign.

Many rooms in the hospital have the switching mechanisms to allow for partial lighting reductions. However, for those areas that do not have this capability, the feasibility of keeping existing wires to supply power and using a low-voltage relay system for control should be considered. In addition to supplemental lighting control for manual switching, automatic lighting control should be considered for some cases. OSHA requirements in STANDARD ANSA-11.1 as well as applicable life safety requirements must be met. In areas requiring two different lighting levels at different times, "inboard-outboard" switching of existing 2 x 4 fluorescent fixtures may be attractive.

All outdoor lighting should be reviewed with security considerations in mind. Must all lights be on all the time? For example, must all lighting be on in an empty parking lot. Saint Joseph's is currently experimenting with low pressure sodium lamps. These may prove to be effective replacements. Where possible, timers should be installed for control of outdoor lighting and coupled with photocells when feasible. The timers should be coordinated with work shifts, visiting hours, and yearly variations of light and darkness.

To assure ongoing savings, in-house programs should be organized to include group relamping, scheduled light fixture maintenance (cleaning and fixture component replacement), and periodic review of required intensity levels. By implementing the various lighting reduction recommendations in coordination with a general lighting reduction program, it is expected that approximately 84,715 KWH (290 BTU) or $2,980 of electrical energy can be saved at Saint Joseph's.

Figure 4

EXAMPLE OF SWITCH PLATE COVER
FOR ENERGY CONSERVATION PROGRAM

Long-Term Conservation Program

The challenge to implement and sustain an energy conservation program is the result of any management and conservation study. The recommendations detailed in this report are the foundation for building a long-term conservation ethic at Saint Joseph's. As new energy sources develop and shifts in existing sources occur, Saint Joseph's will have the resources to accommodate these changes through documented conservation efforts. Although the report reflects a total approach to energy management and conservation, the hospital will, of course, implement the program recommendations in accordance with established hospital goals and other planned programs. The consequences of the energy efforts conducted at Saint Joseph's to date, however, have already resulted in savings that emphasize the positive impact of sound energy management. The desire to continue these efforts and plan for an even greater energy-conserving future is reflected by this program.

Appendix A

ILLUMINATION LEVELS

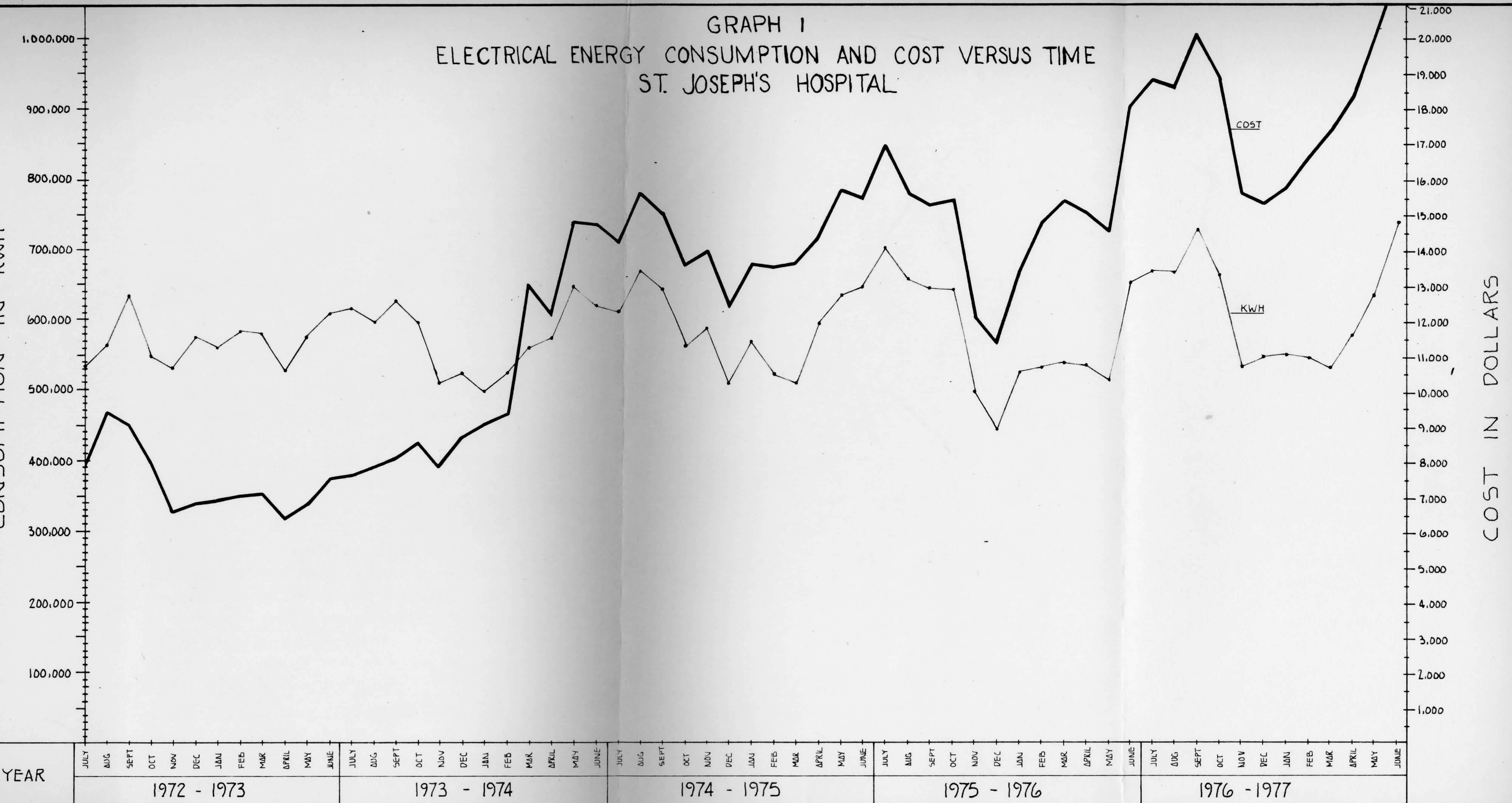
Suggested Illumination Levels

	Footcandles on Tasks
Private Offices	
Reading handwriting in hard pencil or on poor paper, reading fair reproductions	100
Reading handwriting in ink or medium pencil on good quality paper	70
Reading high contrast or well-printed materials	30
Conferring and interviewing	30
General Offices	
Reading handwriting in hard pencil or on poor paper, reading fair reproductions, active filing, mail sorting	100
Reading handwriting in ink or medium pencil on good quality paper, intermittent filing	70
Conference Rooms	
Conferring	30
Note-taking during projection (variable)	30
Rest Rooms and Wash Rooms	30
Corridors, Stairways, Elevators	20
Storage Rooms	
Active—Medium Materials	20
Active—Rough, Bulky Materials	10
Inactive Storage	5
Anesthetizing and preparation room	30
Autopsy and morgue	
Autopsy room	100
Autopsy table	1000
Museum	50
Morgue, general	20
Central sterile supply	
General work room	30
Work tables	50
Glove room	50
Syringe room	150
Needle sharpening	150
Storage areas	30
Issuing sterile supplies	50
Corridor	
General in nursing areas—daytime	20
General in nursing areas—night (rest period)	3
Operating, delivery, recovery, and laboratory suites and service areas	30
Cystoscopic room	
General	100
Cystoscopic table	2500
Dental suite	
Operatory, general	70
Instrument cabinet	150
Dental entrance to oral cavity	1000
Prosthetic laboratory bench	100
Recovery room, general	5
Recovery room, local for observation	70
(EEG) encephalographic suite	
Work room, general	30
Work room, desk or table	100
Examining room	30
Preparation rooms, general	30
Preparation rooms, local	50
Storage, records, charts	30
Emergency operating room	
General	100
Local	2000
EKG, BMR, and specimen room	
General	30
Specimen table	50
EKG machine	50

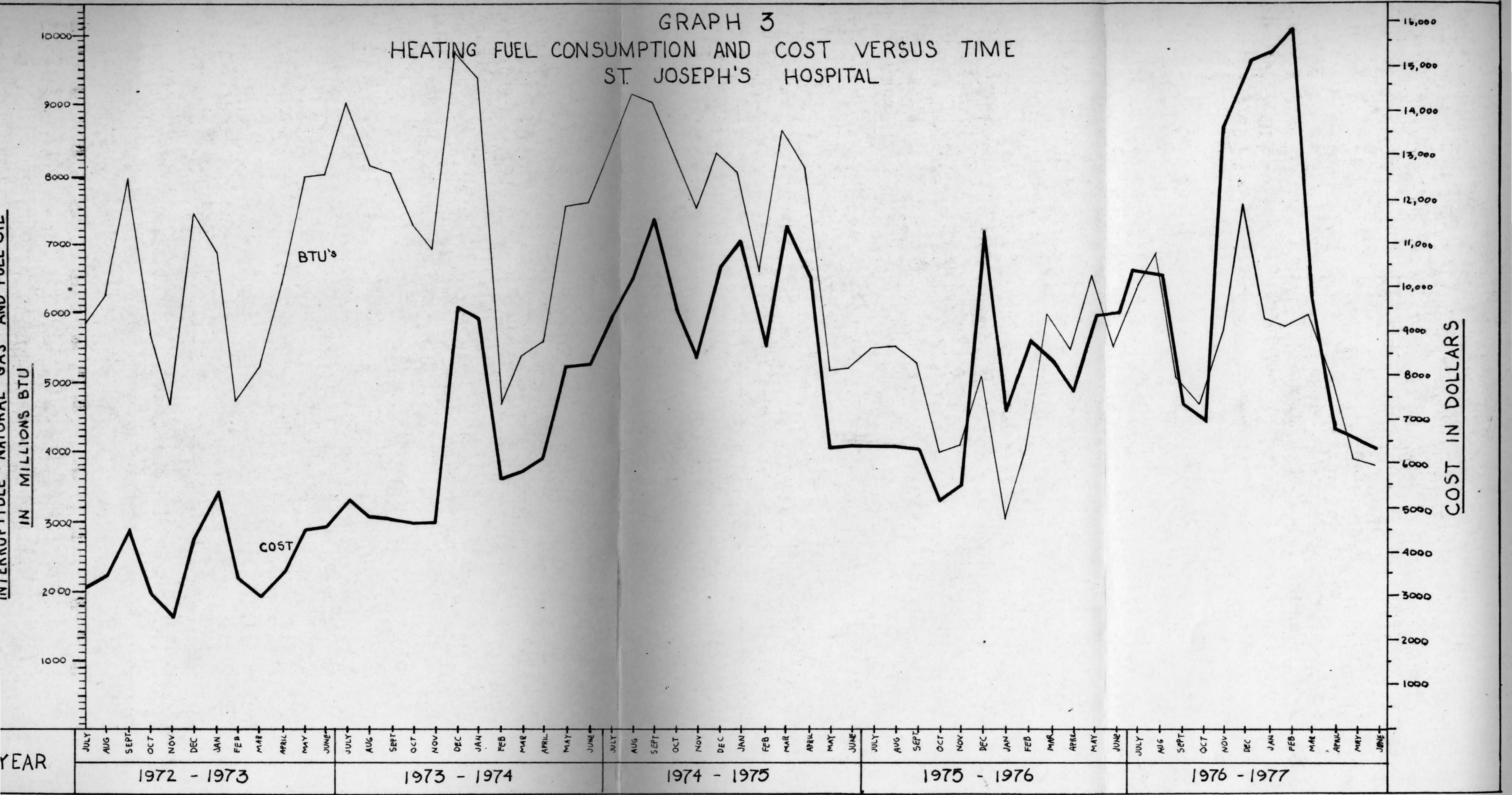
	Footcandles on Tasks
Examination and treatment room	
General	50
Examining table	100
Exits, at floor	5
Eye, ear, nose, and throat suite	
Darkroom (variable)	0-10
Eye examination and treatment	50
Ear, nose, throat room	50
Flower room	10
Formula room	
Bottle washing	30
Preparation and filling	50
Fracture room	
General	50
Fracture table	200
Splint closet	50
Plaster sink	50
Intensive care nursing areas	
General	30
Local	100
Laboratories	
General	50
Close work areas	100
Linens	
Sorting soiled linen	30
Central (clean) linen room	30
Sewing room, general	30
Sewing room, work area	100
Linen closet	10
Lobby (or entrance foyer)	
During day	50
During night	20
Locker rooms	20
Medical records room	100
Nurses station	
General—day	70
General—night	30
Desk for records and charting	70
Table for doctor's making or viewing reports	70
Medicine counter	100
Nurses gown room	
General	30
Mirror for grooming	50
Nurseries, infant	
General	30
Examining, local at bassinet	100
Examining and treatment table	100
Nurses station and work space (see **Nurses Station**)	
Obstetrical suite	
Labor room, general	20
Labor room, local	100
Scrub-up area	30
Delivery room, general	100
Substerilizing room	30
Delivery table	2500
Clean-up room	30
Recovery room, general	30
Recovery room, local	100
Patients' rooms	
General	20
Reading	30
Observation (by nurse)	2

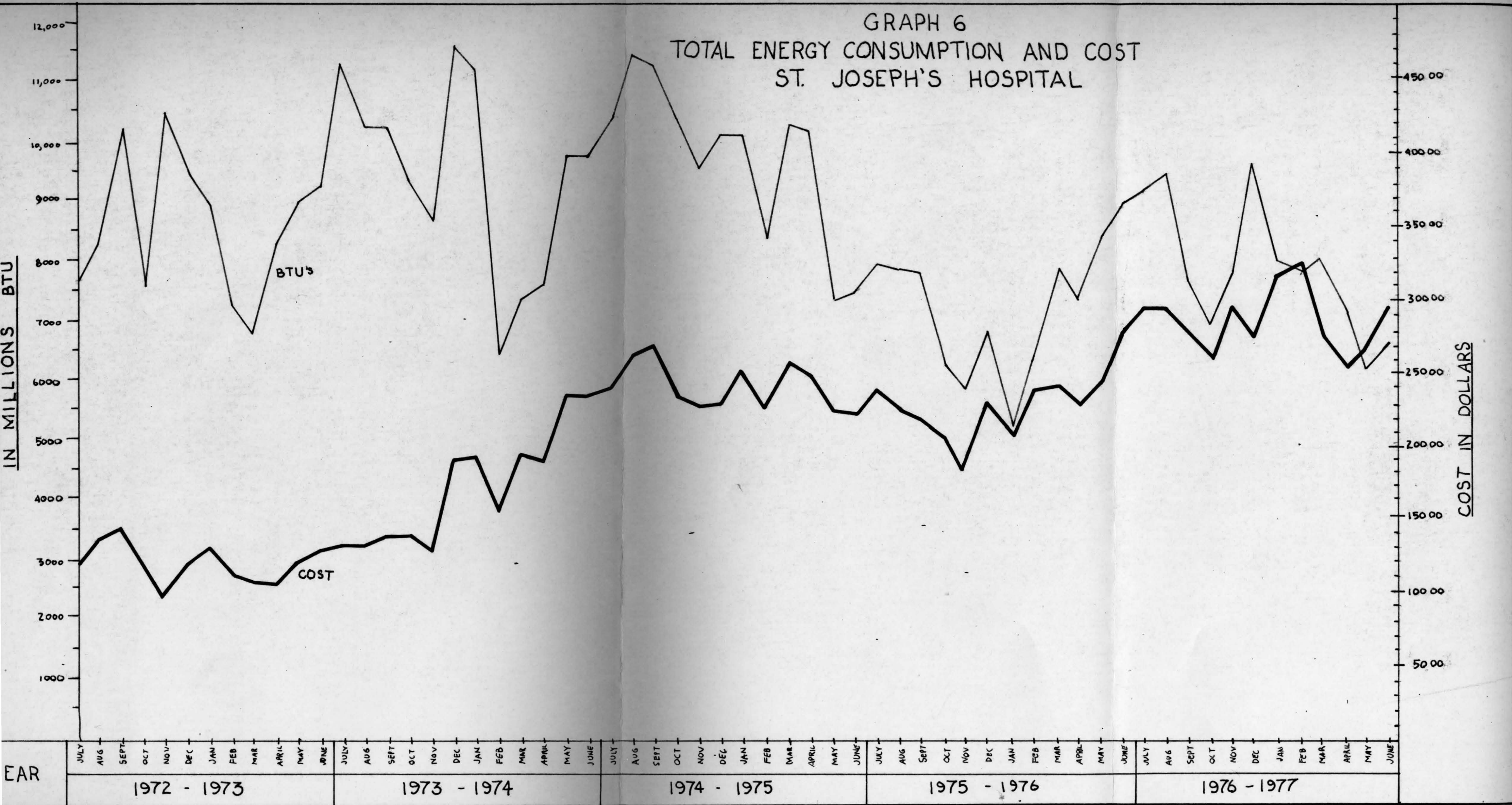
	Footcandles on Tasks
Night light, maximum at floor (variable)	0.5
Examining Light	100
Toilets	30
Pediatric nursing unit	
General, crib room	20
General, bedroom	10
Reading	30
Playroom	30
Treatment room, general	50
Treatment room, local	100
Pharmacy	
Compounding and dispensing	100
Manufacturing	50
Parenteral solution room	50
Active storage	30
Alcohol vault	10
Radioisotope facilities	
Radiochemical laboratory, general	30
Uptake or scanning room	20
Examining table	50
Retiring room	
General	10
Local for reading	30
Solarium	
General	20
Local for reading	30
Stairways	
Surgical suite	
Instrument and sterile supply room	30
Clean-up room, instrument	100
Scrub-up area (variable)	200
Operating room, general (variable)	200
Operating table	2500
Recovery room, general	30
Recovery room, local	100
Anesthesia storage	20
Substerilizing room	30
Therapy, physical	
General	20
Exercise room	30
Treatment cubicles, local	30
Whirlpool	20
Lip reading	150
Therapy, occupational	
Work area, general	30
Work tables or benches, ordinary	50
Work tables or benches, fine work	100
Toilets	30
Utility room	
General	20
Work counter	50
Waiting rooms or areas	
General	20
Local for reading	30
X-ray suite	
Radiographic, general	10
Fluoroscopic, general (variable)	0-50
Deep and superficial therapy	10
Control room	10
Film viewing room	30
Darkroom	10
Light room	30
Filing room, developed films	30
Storage, undeveloped films	10
Dressing rooms	10

Source: Illuminating Engineering Society

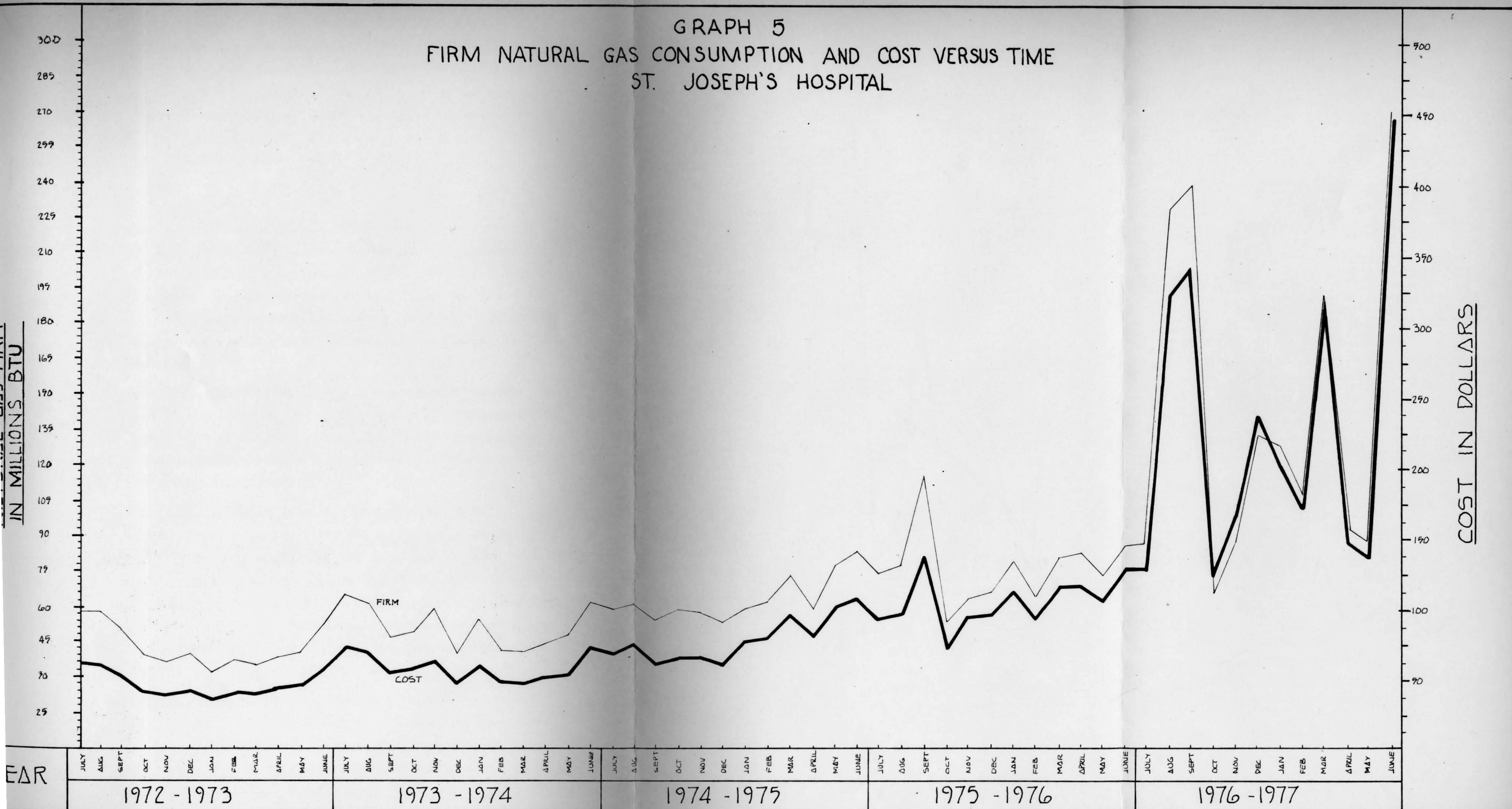


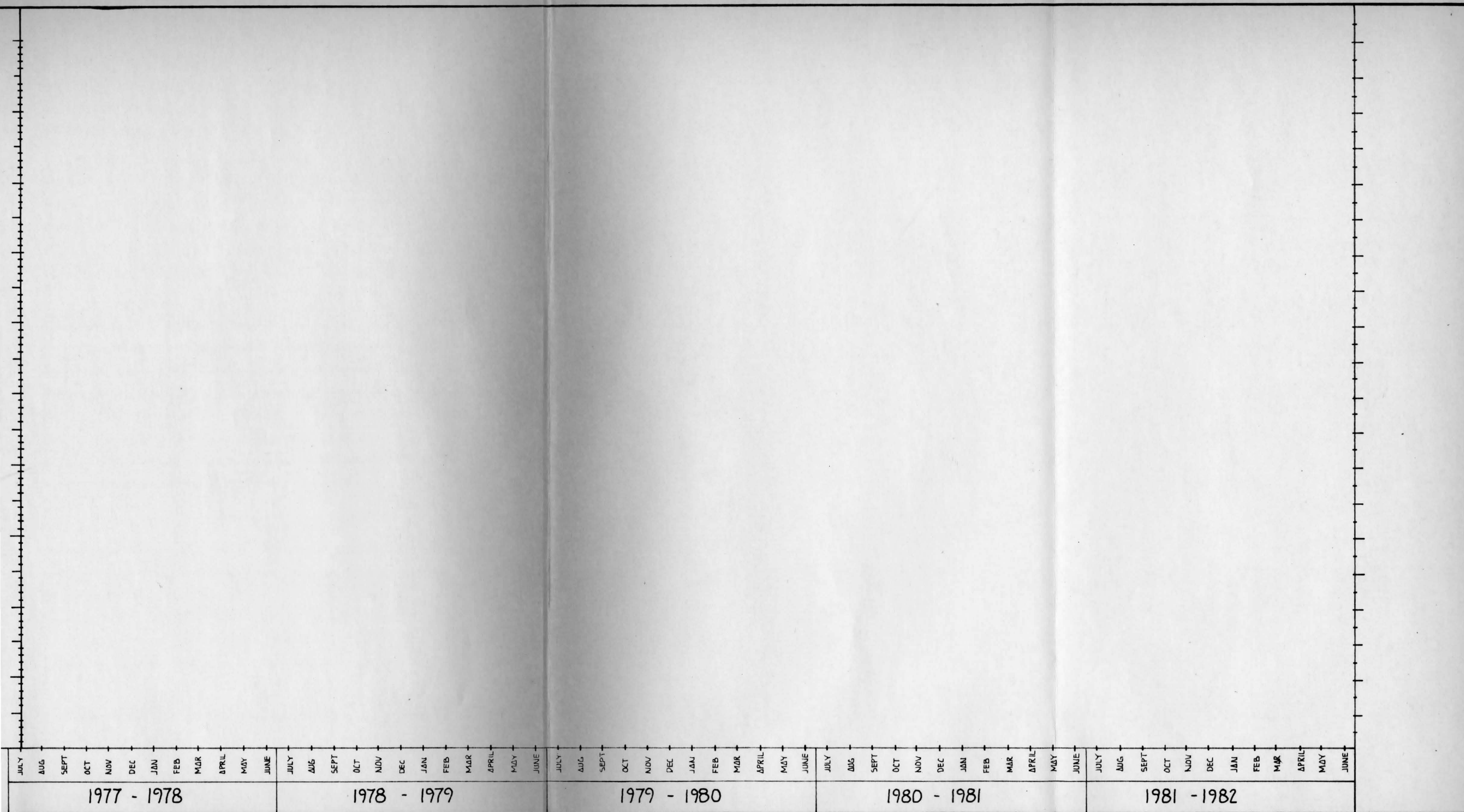
GRAPH I
ELECTRICAL ENERGY CONSUMPTION AND COST VERSUS TIME
ST. JOSEPH'S HOSPITAL
COST
KWH
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
21,000
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
COST IN DOLLARS
YEAR
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APRIL MAY JUNE
1972 - 1973
1973 - 1974
1974 - 1975
1975 - 1976
1976 - 1977


GRAPH 3
HEATING FUEL CONSUMPTION AND COST VERSUS TIME
ST. JOSEPH'S HOSPITAL
BTU'S
COST
IN MILLIONS BTU
COST IN DOLLARS
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APRIL MAY JUNE
YEAR
1972 - 1973
1973 - 1974
1974 - 1975
1975 - 1976
1976 - 1977



GRAPH 6
TOTAL ENERGY CONSUMPTION AND COST
ST. JOSEPH'S HOSPITAL
IN MILLIONS BTU
COST IN DOLLARS
BTU'S
COST
12,000
11,000
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
450 00
400 00
350 00
300 00
250 00
200 00
150 00
100 00
50 00
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APRIL
MAY
JUNE
EAR
1972 - 1973
1973 - 1974
1974 - 1975
1975 - 1976
1976 - 1977


GRAPH 5
FIRM NATURAL GAS CONSUMPTION AND COST VERSUS TIME
ST. JOSEPH'S HOSPITAL
IN MILLIONS BTU
COST IN DOLLARS
FIRM
COST
1972 - 1973
1973 - 1974
1974 - 1975
1975 - 1976
1976 - 1977


JULY AUG SEPT OCT NOV DEC JAN FEB MAR APRIL MAY JUNE
1977 - 1978
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APRIL MAY JUNE
1978 - 1979
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APRIL MAY JUNE
1979 - 1980
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APRIL MAY JUNE
1980 - 1981
JULY AUG SEPT OCT NOV DEC JAN FEB MAR APRIL MAY JUNE
1981 - 1982